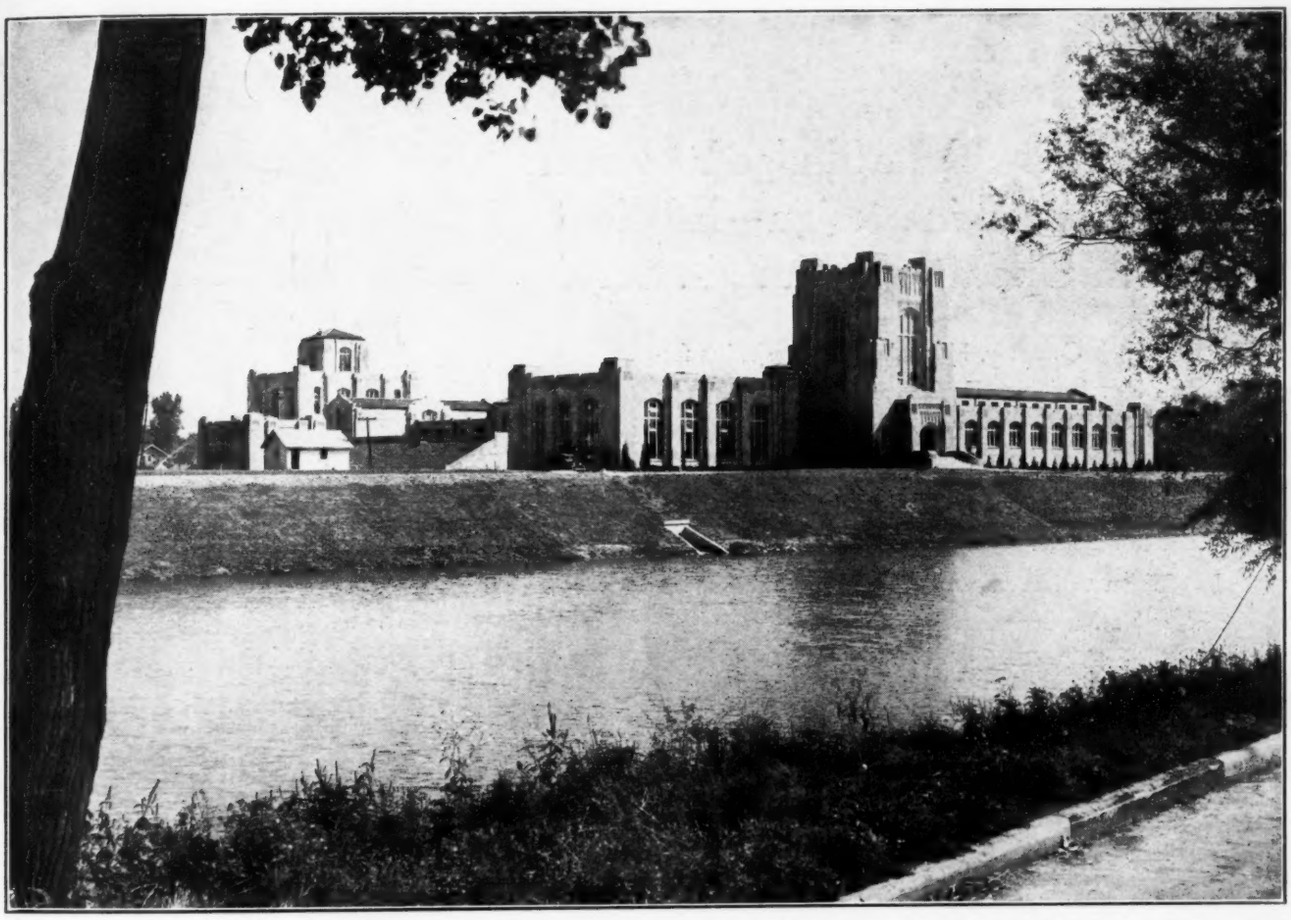
WATER WORKS AND SEWERAGE

December, 1934 — Editor — Vol. LXXXI. No. 12



The Water Works of Fort Wayne, Ind., Filtration-Softening Plant (Left Rear) and Pumping Station. (Hoad, Decker, Shoecraft & Drury, engineers)

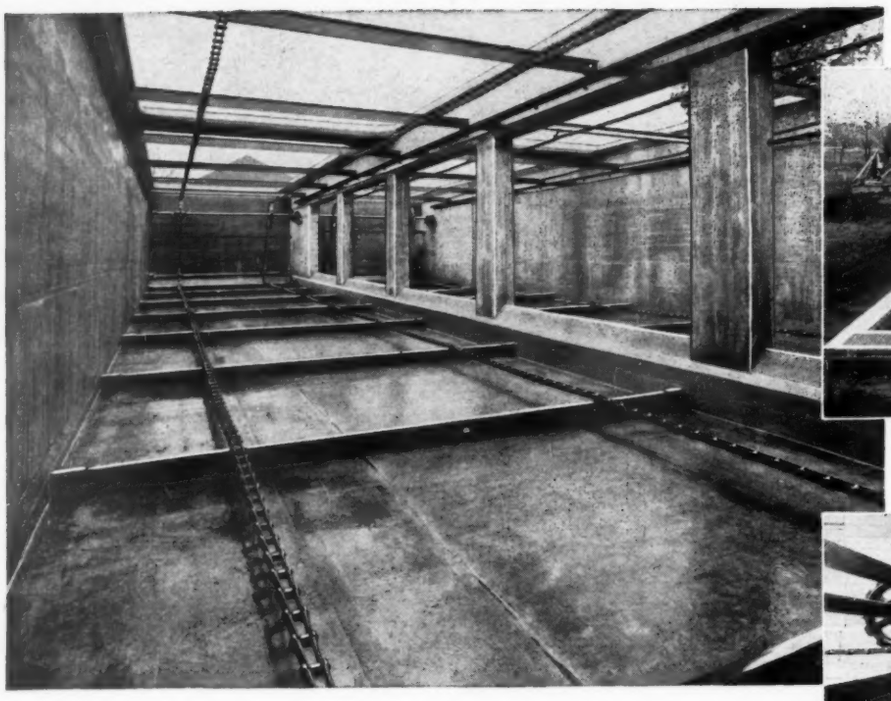
IN THIS ISSUE

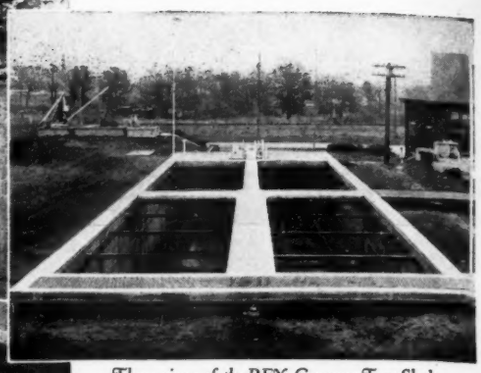
Sludge Dewatering at Baltimore, Md.

Comparative Notes on Field Joints for Large Steel Pipe

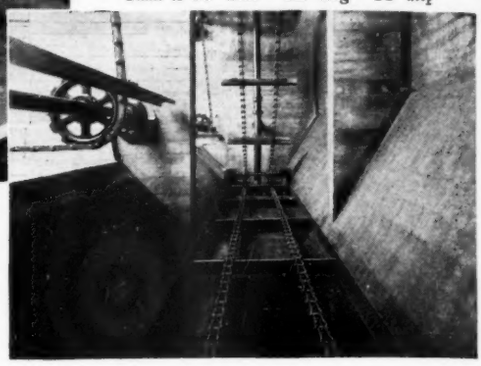
Reports on Ohio Conferences on Sewage Treatment and Water Purification

Determining Deterioration of Mains in Distribution Systems and Experiences at Tucson, Ariz.





Three views of the REX Conveyor Type Sludge Removers, at the Elgin, Illinois Sewage Disposal Plant
Tank is 33′ wide—92′ long—11′ deep



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WATER WORKS & SEWERAGE

L. H. ENSLOW,
Editor

LEADING ARTICLES To Appear in the Next and Subsequent Issues

Langdon Pearse, Sanitary Engineer, of the Chicago Sanitary District, will review "The Devolpments of 1934 in Sewerage Practices" in our February issue. The review covering "Developments in Water Supply and Purification" will appear in the January issue as a contribution by I. W. Mendelsohn.

J. E. Herring, Supt. of Meters, Jacksonville, Fla., will describe methods of reading and billing; and practices followed in maintenance, testing and repairing meters, in shop and field, which are employed by the Jacksonville Water Department.

"Sewage Sludge, Its Preparation and Sale" constitutes a story, relating four years of experience in marketing digested slug as fertilizer at Dayton, O., by M. W. Tatlock, Supt. of Dayton's Treatment Works. Purchasing sludge from nearby plants to make up local deficiency in order to meet demand is something new in sludge disposal experience.

"Practices in Water Meter Replacements" as developed and applied in Los Angeles are to be disclosed by Chas. L. Ruckman, Asst. Supt. of Meter and Service Div., of the Los Angeles Water Department.

H. H. Hendon, in the Dec. 1933 issue of WATER WORKS AND SEWERAGE, described the design of a projected chemical precipitation sewage treatment plant under construction at Birmingham, Ala. He will shortly disclose operating results at this plant during 6 months of operation and cite cost data.

John R. Baylis will discuss "Washing of Rapid Sand Filters" which constitutes the fourth of a series of articles dealing with "Filtering Materials for Rapid Filters." Mr. Baylis' contribution was scheduled for this issue, but is being held over because its length precluded its use in full.

"Benefits Which Result from Beautification of Plants and Grounds" is a subject dealt with as the result of experiences by Edw. H. Ruehl as Engineer and Manager of Water and Sewage Utilities in a small Southern municipality. At little expense, he beautified a small plant made a park of the grounds—but let him tell this story of interest to every superintendent.

Anthracite Coal as a Filtering Material —is to be discussed by H. G. Turner and G. S. Scott of the Anthracite Institute. This article is the last of a series and discloses reasons for the filtering performance and long filter runs with crushed and graded anthractie filter media.

"Methods of Eliminating Check Valve Slam" which have proven practical and effective in the Los Angeles County Sanitation Districts is to be described by H. K. Palmer.

A. M. Buswell, Chief, State Water Survey, Urbana, Ill., will present an article dealing with methods of "Treating Beer Slop and Similar Wastes" and J. DeMartini, California Dept. of Health will describe methods of "Disposal of Winery Wastes."

Vol. LXXXI, No. 12

CONTENTS for DECEMBER 1934

Comparative Notes on Field Joints for Larger Diameter Steel Pipe . . 397
By W. C. CURD
Consulting Engineer, Cincinnati, O.

Sludge Dewatering at the Baltimore Sewage Works 403
By C. E. KEEFER
Principal Assistant Engineer, Bureau of Sewers, Baltimore, Md.

Determination of Deterioration of Mains in Distributing Systems . . . 408
By JOHN A. CAROLLO
Of Headman-Ferguson, Engineers, Phoenix, Ariz.

Evaluating the Deterioration of Mains in the Tucson Distribution System 410
By L. R. BURCH
Tucson Water Department, Tucson, Ariz.

Ohio Conference on Sewage Treatment 414

Ohio Conference on Water Purification 419

Pipe Locating Experiences with the Terrometer 421
By THOMAS L. AMISS
Superintendent Department of Water and Sewerage, Shreveport, La.

Editorials 423

New Equipment 425

Published monthly by the GILLETTE PUBLISHING CO., Daily News Building, Chicago, Ill.

Entered as Second Class Matter, June 2, 1931, at the Post Office at Chicago, Ill., under the Act of March 3, 1879. Published monthly at 400 W. Madison Street, Chicago, Ill. Per copy 25c. Subscription rates $2.00 per year. Canadian and Foreign, $3.00 per year. Copyright, 1934, by Gillette Publishing Company, Publishers of: Water Works and Sewerage, Roads and Streets, Oil and Soap, The Art of Mosaics and Terrazzo, Road and Street Catalog and Data Book, Water Works Catalog and Data Book.

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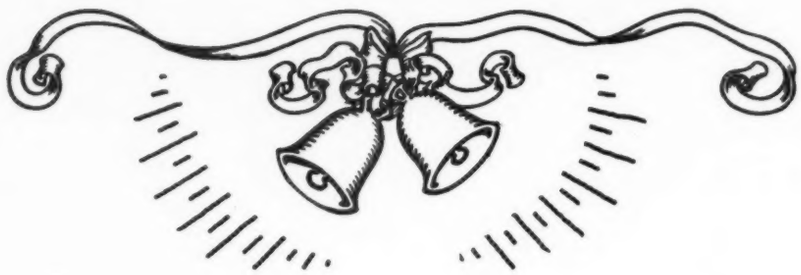
Chicago Office, Daily News Building. Lakewood, Ohio Office, 1514 Cohasett Ave. New York Office, 420 Lexington Avenue. San Francisco Office, 155 Montgomery Street.

Addresses will be changed as frequently as desired, upon notification; not otherwise. Changes of address should be sent in at least two weeks before the date of the next issue of *Water Works and Sewerage*, in order for them to be effective for that number. Immediate notice should be given of any delay in the receipt of the magazine.



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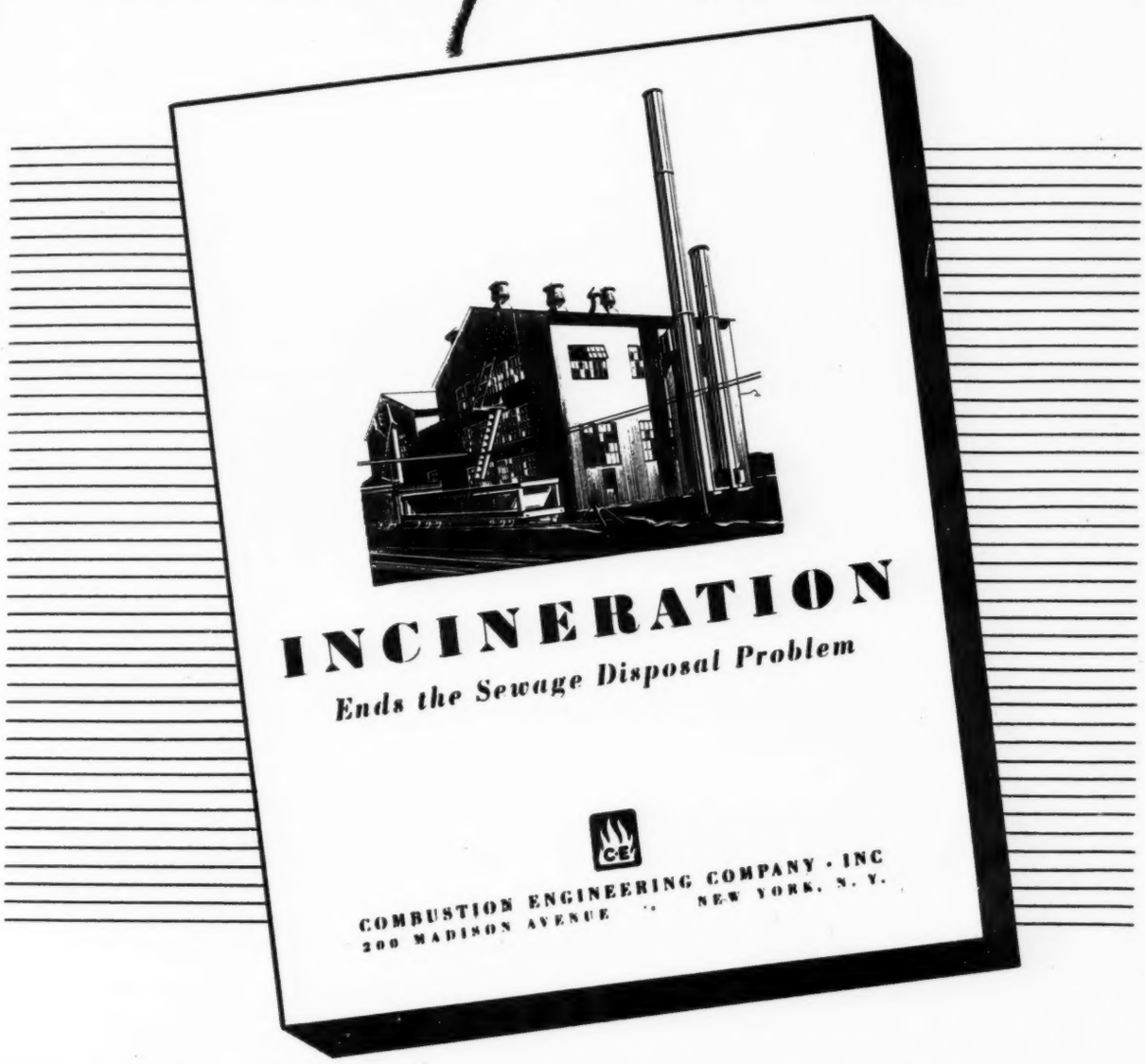

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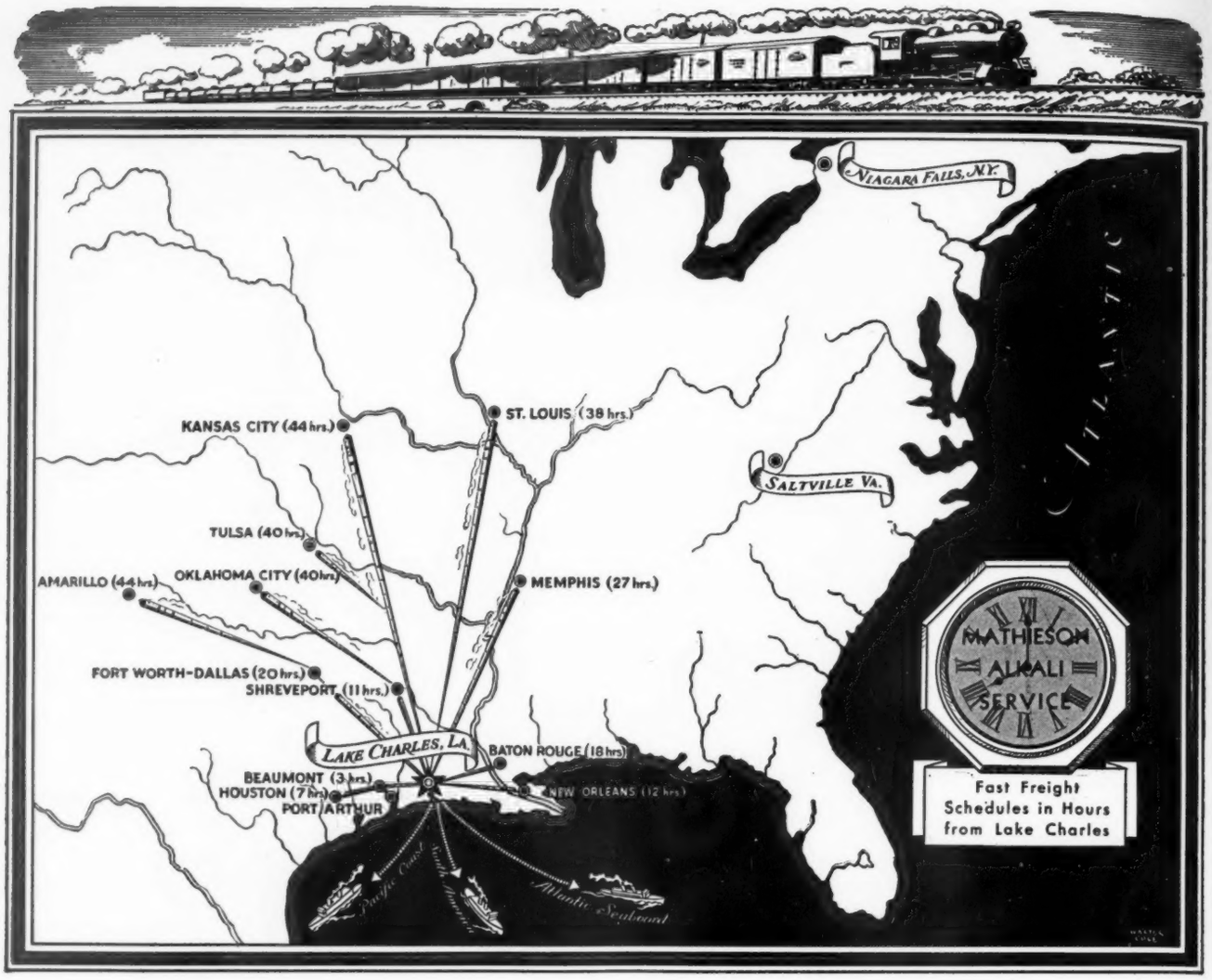

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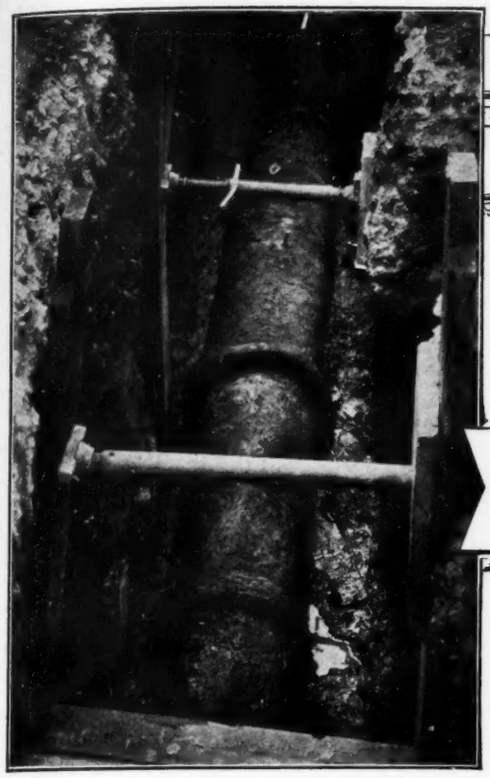

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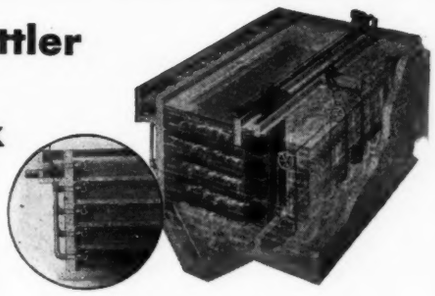

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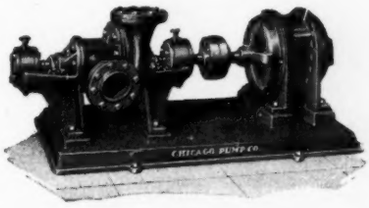

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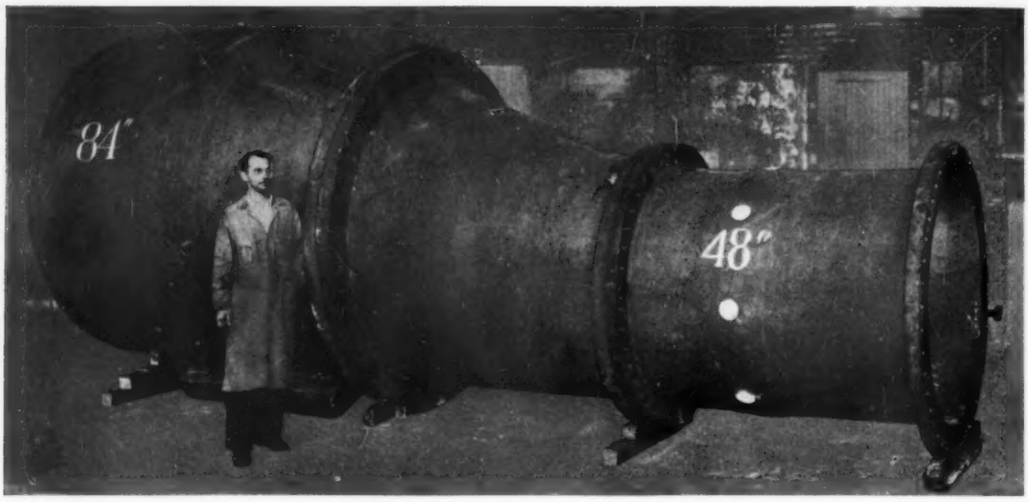

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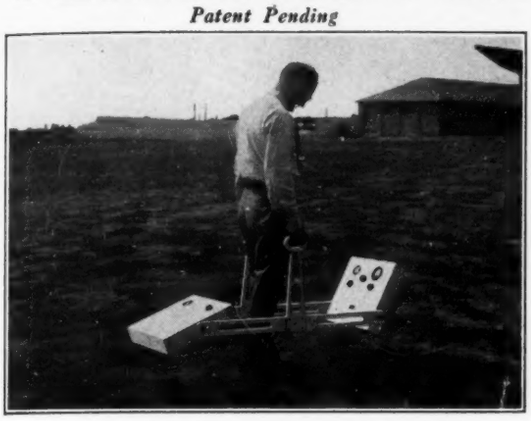

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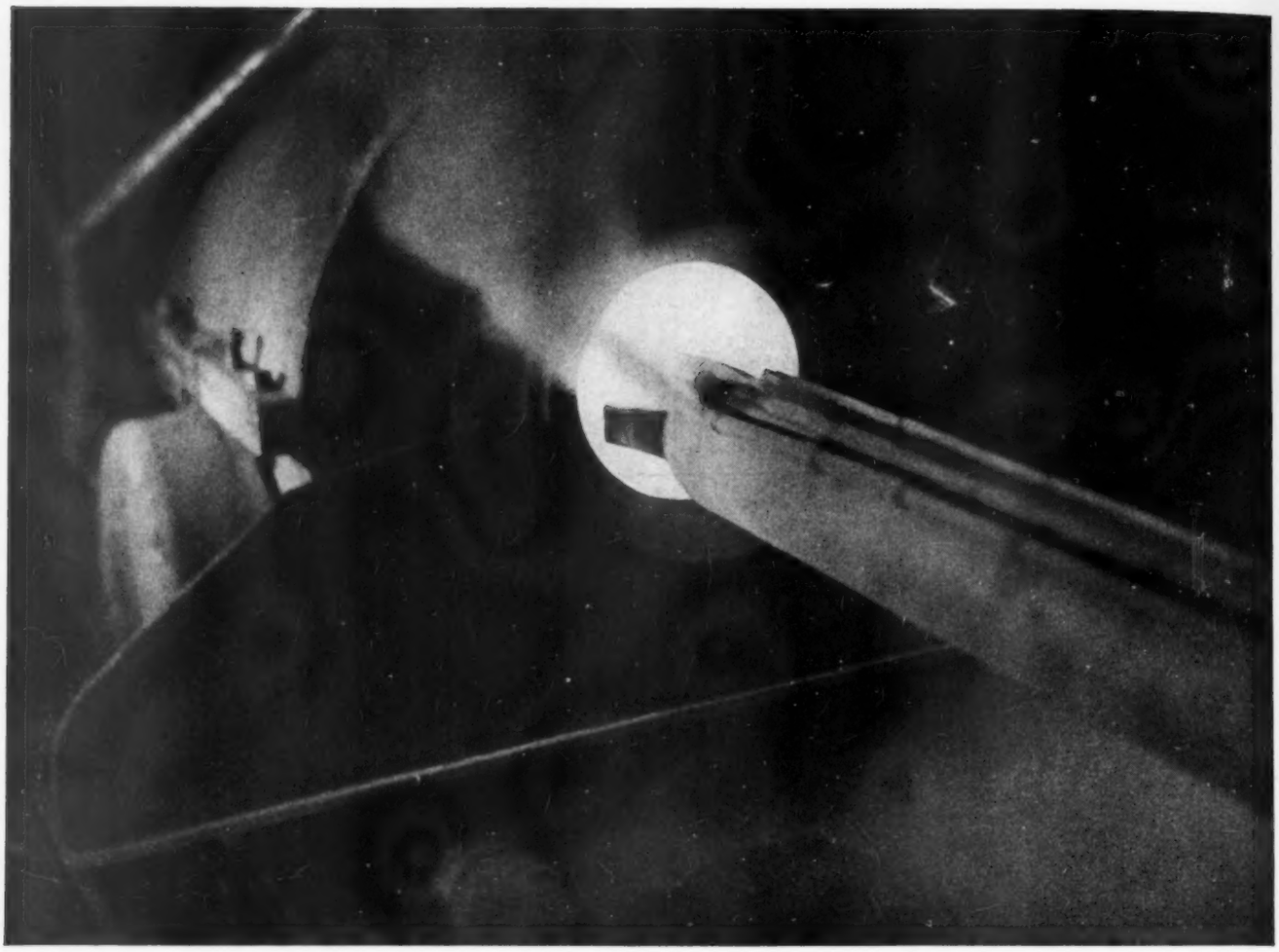

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WATER WORKS AND SEWERAGE
A GILLETTE PUBLICATION
VOL. LXXXI DECEMBER, 1934 NO. 12

St. Joseph River Crossing on the Fort Wayne Pipe Line Project

COMPARATIVE NOTES ON FIELD JOINTS FOR LARGE DIAMETER STEEL PIPE

Based on Recent Installation of 42-Inch Steel Supply Main at Fort Wayne, Ind.

By W. C. CURD
Consulting Engineer, Cincinnati, Ohio

The increasing use, in recent years, of steel pipe for water mains has given rise to several important questions in the water works fraternity concerning the most satisfactory type of pipe joint for such installations.

A considerable part of the difficulty can be ascribed to the lack of dependable information. The purpose of this article is to remedy this situation, insofar as possible, by supplying actual comparative facts and figures on several types of field joint construction. It is hoped that the data presented will be of definite help to those who, in the face of much conflicting information, must yet carry the responsibility for a highly important decision—the selection of the best type of pipe joints.

Before going any further, I want to add one word. This is a report of my own experience and I offer it as such. Facts and figures presented here, however, are based on actual operations in the field and have been verified for accuracy.—W. C. C.

IN January, 1934, the city of Fort Wayne, Indiana, put into operation its very modern and up-to-date water supply plant. Extensive improvements, looking to a change from a well system to filtered river water, were carried to completion over a period of several years.

A filtration plant,* with a daily capacity of twenty-four million gallons, an underground reservoir of twenty million gallons capacity and a pumping station,* were installed at junction of St. Marys and St. Joseph rivers, near the business district at Fort Wayne. An imposing concrete dam was constructed across St. Joseph River near the northerly limits of the city. Incorporated in the dam is an hydroelectric plant and pump house, the hydroelectric equipment supplying current for pump operation, and also serving as a feeder for the present municipal power plant. Water is now taken from St. Joseph River, at the dam, and pumped to the filtration plant through a 42-in. steel supply main, with a capacity of forty million gallons per day at 40 pounds pressure.

This article will describe some of the construction features of the pipe line, and, since the type of field connections employed made many of the operations quite simple and rapid, some contrasts will be drawn with other types of connections, in order that respective merits may be appreciated.

Prior to awarding contract for construction, bids were invited on several classes of pipe line materials, such as

*Pictured on the front cover of this issue.

concrete, cast iron, steel and Toncan iron, with alternate types of field joints. From these bids was selected, as being most economical, pipe made of ⅜-inch Toncan iron, with Dresser type couplings for field connections.

Route and Curvature

Since the route of the supply main was confined to public streets and city owned property, and along right and left banks of St. Joseph River, considerable horizontal curvature was introduced. A crossing under St. Joseph River, as well as valve chamber connections at each end of the line also necessitated several sharp vertical bends.

A plan and profile of the line is shown in Fig. 1, which also gives the locations of the several field tests for tightness of line, which will be referred to later herein.

In the total length of line (12,374 feet) approximately 3,230 feet, or 26 per cent, were in horizontal curves. For curves with a radius of less than 400 feet, totaling 1,110 feet, special curved sections on 20-ft. chord lengths were used but all other curves were formed with straight sections of 40-ft. standard lengths. This was accomplished with Dresser Couplings, by deflecting each 40-ft. section as the chord of an arc. This left an opening between ends of abutting pipe on the outside of curves. No difficulty, however, was encountered in making tight joints, for there was no change brought about in the fit of the rings or gaskets. After each deflected joint was set to position, the center ring of the coupling was driven with a sledge, backward or forward as the case demanded, so that the stop or center bead in the ring was always centered in the gap or opening.

The accompanying tabulation (Table I) gives the approximate width of gap under the center ring of the coupling between abutting ends of the 42-in. diameter straight pipe, with the corresponding radii of each curve so formed. The flexibility of such a method for laying out curves with straight pipe is apparent and worthy of note.

To counteract any friction to flow, which might be added as a result of the openings left between pipe ends, the gap was filled out in the field with pipe coating of the required consistency, so that a uniformly smooth surface was presented to the flow.

In Plate 1 is shown a curve, with radius of 150 feet, which was formed with special curved sections. Plate 2 shows a curve formed with 40-ft. sections of straight pipe.

TABLE I. GAP BETWEEN PIPE ENDS AT JOINTS ON CURVING LINE

Total Gap—Inches	Corresponding Radii—Feet
2⅞	650
2⅝	700
2⅜	820
1½	1425

The above described method of forming curves was found extremely convenient at one point on the Fort Wayne project where the line had to be shifted three feet in order to save a valuable tree, which was directly on center line of a sharp curve.

Vertical curves, made necessary by the general rise and fall in the gradient, were formed with straight pipe, in the same manner as described for horizontal curves, and without using any special curved sections. Both horizontal and vertical deflections, when required, could readily be made in the same coupling.

In general, this method of deflection, as compared with riveted or welded field connections, seems to have several definite advantages. It offers a very simple and practical method of obtaining curvature without the necessity of factory-made specials, specially beveled pipe ends, reaming and changing of rivet holes, or slow and expensive filling-in of increased amounts of welding rod on outside of curves.

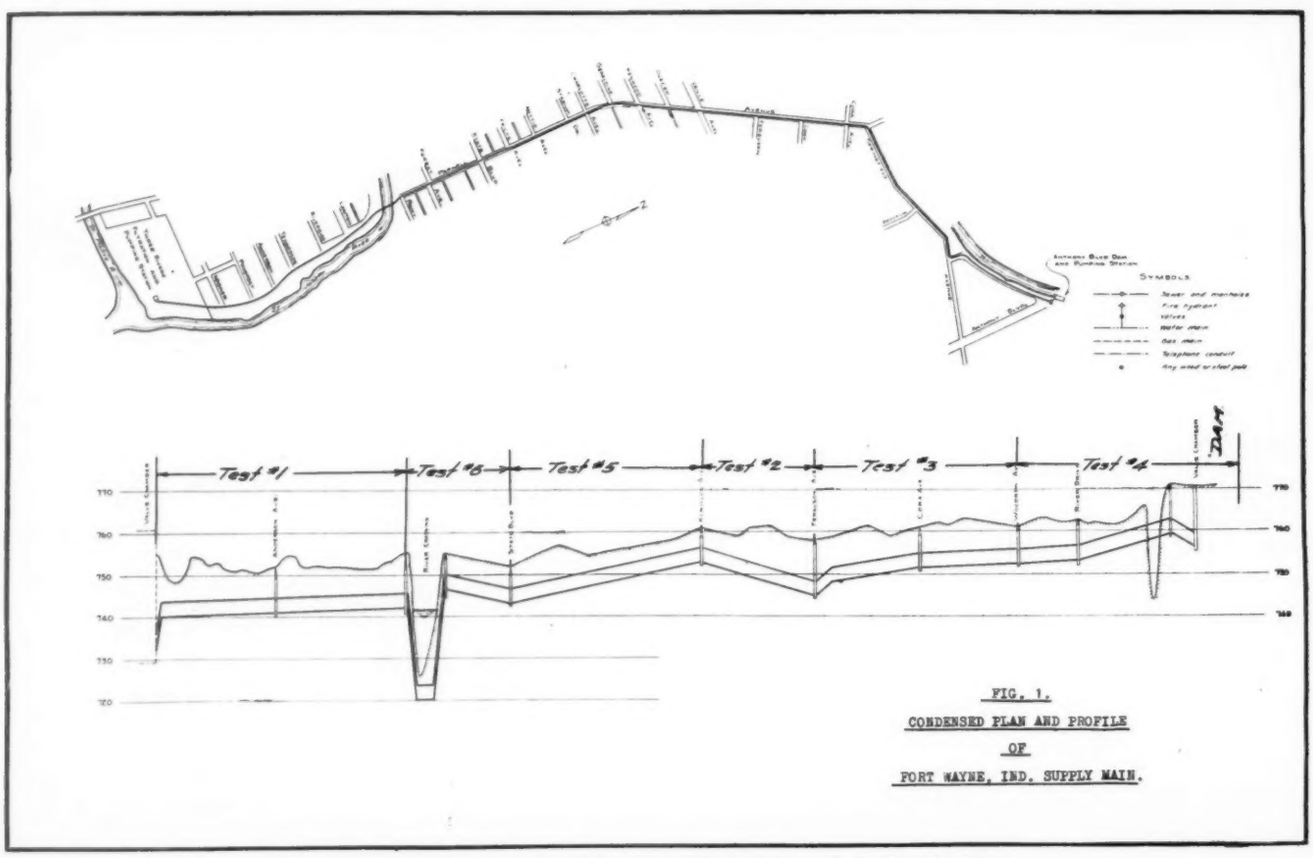

Fig. 1.—Condensed Plan and Profile of Fort Wayne, Ind., Supply Main.

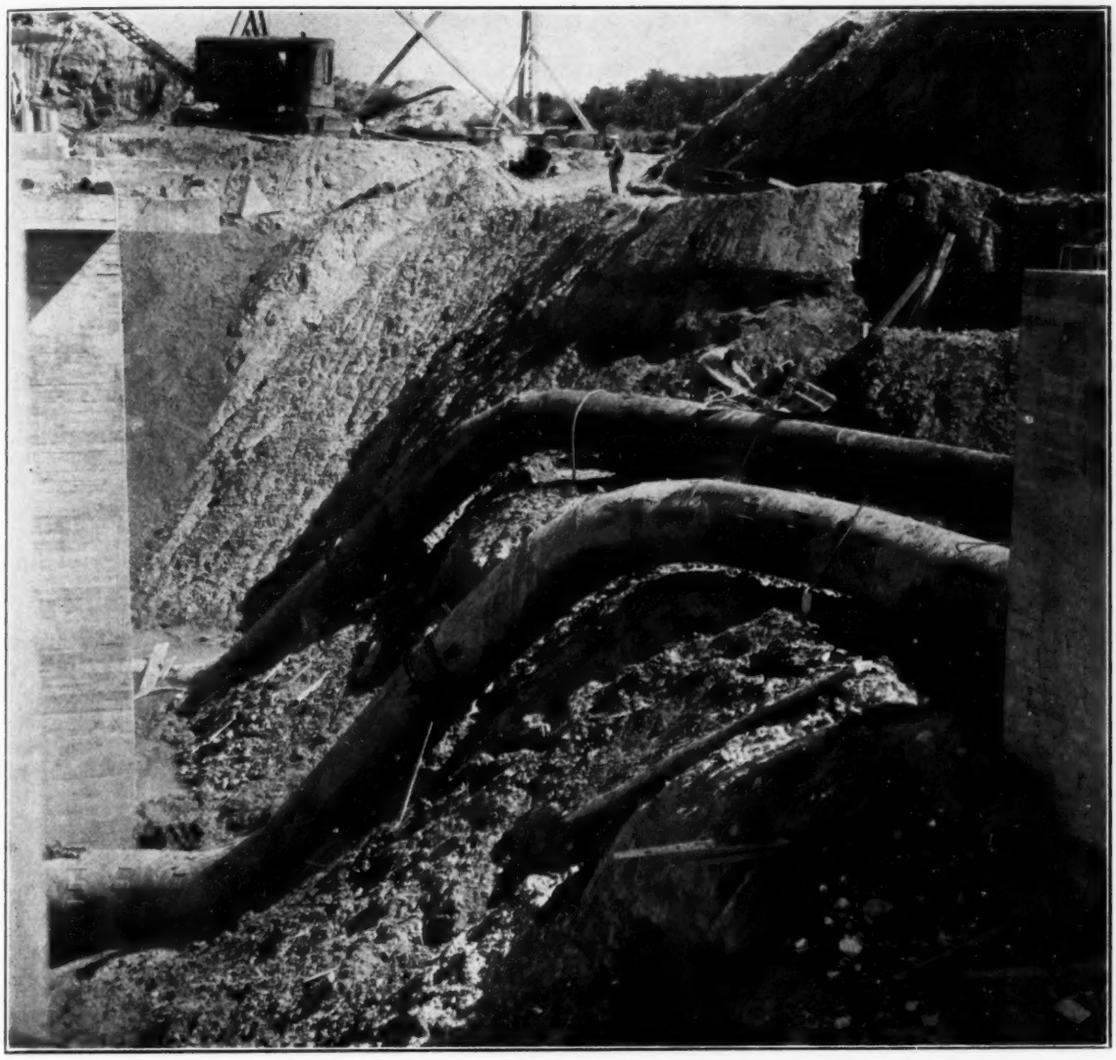

Plate 3.—Two 36-inch Diameter Lines Connecting Valve Chamber to Pumphouse. Note Vertical and Horizontal Bends; Also Welded Anchoring Clips Just Behind the Couplings.

No provision was included in the Fort Wayne plans and specifications for any form of anchorage on curves or bends, nor was any ordered during the progress of the work, although application for same was several times made by the contractor. Omission of such provisions can probably be accounted for by the low operating pressure of 40 pounds per square inch, for which the line was designed. However, since hydrostatic pressure of 100 pounds per square inch was specified for the field test, anchorage and blocking on sharp curves and bends had to be used to prevent movement at joints, while tests were under way.

On horizontal curves and reverses, the pipe was blocked against the trench walls with timber and then backfilled.

Vertical bends or elbows were quite simply anchored by welding four sets of ½ x 3 inch clips to each end of each special pipe section, just back of the coupling, and connecting them with 1 x 22 inch bolts placed over and across the coupling (see Plate 3). Observations during and after tests did not show leakage or movement at any of the joints so anchored.

Expansion and Contraction

There were no expansion joints installed in this line nor were any needed. Expansion joints were an unnecessary precaution because the form of coupling employed permits expansion or contraction to take place in each length of pipe and therefore every joint is in itself an expansion joint. The rubber compounded gaskets, due to their elastic grip, enable the pipe to move in and out as temperature changes occur, without danger of leakage. This feature of the Dresser type of coupling is to the writer's mind a very desirable asset.

Description of Couplings Used

Without the availability of an adequate illustration, the following description may be helpful to those not familiar with the Dresser type of coupling. It consists of a wide horizontal steel cylindrical ring known as the center ring, two circular rubber compounded gaskets, two outer rings or followers, and a variable number of bolts depending on the coupling size. The followers and center ring are made with an inside diameter slightly larger than the nominal outside diameter of the pipe in order to compensate for allowable variations in pipe diameters; the gaskets are made to give a stretch-fit over pipe of a minimum allowable outside diameter for a nominal size. The center ring contains a stop (rolled-in bead) at midcenter of its interior face, which serves to center the ring and produce an equal lapping over of the abutting ends of the pipe.

The edges of the center ring also have a flare or outward taper to receive the gaskets. The outer rings or followers stand perpendicularly to the pipe, with a rim

Plate 2.—The 42-inch Diameter Line on Curve Formed with 40-foot Sections of Straight Pipe. In Foreground Is Ravine Crossing Where Pipe, Later Covered with Earth, Is Supported by Concrete Piers.

or flange rolled in one face at such distance from the exterior surface of the pipe as to retain or form a recess, into which fits the outer edge of the gasket. The outer rings are punched with oval holes, uniformly spaced, through which are inserted bolts with a special track-head to match the holes; this is done to prevent the bolts from turning while the nuts are being drawn up. Pressure is exerted, by the followers against the gaskets, by drawing up the bolts which wedge the gaskets tightly against the exterior surface of the pipe and under the flared or tapered edges of the center ring. Thus, a watertight connection is formed.

To apply a coupling, an outer ring (seen in Plate 1) is placed over the end of each pipe. Next, the rubber gaskets are slipped on the ends of the two pipes with the beveled edges facing the joint. The cylindrical center ring is then forced over the end of the laid pipe, until the stop or center bead fits against the end of the pipe. Next, the abutting end of the other pipe is similarly brought in. After the ends are properly set against the stop in the center ring, the gaskets are pushed in and under the flared edges of the center ring. Then the outer rings (followers) are brought up against the gasket and revolved until the bolt holes match, after which the bolts are inserted and nuts run up by hand, preparatory to applying wrenches.

In the Fort Wayne installation, the center ring was ⅜ x 10 inch, the gaskets ⅛ x ⅝ x 1½ inch and the outer rings or followers ½ x 2⅜ inch. Twenty-four ¾ x 14 inch bolts were used on each coupling. The couplings weighed 330 pounds each when completely assembled.

All pipe furnished had plain ends, with two electrically welded longitudinal seams, because plain ends only are required for Dresser couplings. The exterior bead on the welded seams was ground down, by the pipe manufacturer, until it was flush with the general surface for a distance of 7 inches from the ends of the pipes. This was necessary so that the rings might slip freely over the pipe ends and the gaskets might make a smooth contact around the entire exterior surface of the pipe.

Removal of Pipe Coating at Joints

The pipe was vertically dipped, by the manufacturer, in a hot emulsion of standard pipe coating, which made it necessary that the ends of all pipe sections be scraped clean of outside coating before the couplings were applied. The manufacturer tried a scheme of applying white lead to the pipe ends before dipping, to prevent the dip coat from adhering to the metal, but it was not found that this particularly aided in the removal of the coating.

Preparatory to commencement of laying operations, pipe and couplings were distributed along the route, well in advance of daily requirements, and two men were assigned to scrape the coating from the ends. They were kept at it until enough sections had been cleaned, so that laying progress would not be delayed after commencement of operations. The work was then turned over to the regular laying gangs.

Two men, working eight hours, each scraped and cleaned an average of eight sections of pipe per day. Operations were most rapid in the early morning hours, when the coating was cool and somewhat brittle but as the heat of the day approached, the work was greatly slowed up by the tacky consistency of the coating.

On this work some interesting comparisons were possible since both riveted and welded field connections also require that the coating be removed from the inside of the pipe as well as from the outside for either riveting or welding. More care, too, must be exercised to provide a clean, direct metal-to-metal contact in making these joints and also to prevent fouling in the case of welding.

As to offering a direct out-and-out comparison of the actual area in square inches that must be cleaned for the three types of joints, I am somewhat hesitant, for this is a matter accompanied by so many variables that no definite rule can be laid down. Possibly it might be best to say that on the Fort Wayne job, two men working eight hours, each scraped and cleaned an average of eight sections of pipe per day. With these figures, the reader will be able to make comparison of his own with respect to riveted or welded joints.

In general, it was my conclusion that the type of installation on the Fort Wayne job lessened considerably the expense of scraping and cleaning pipe ends, inside and out.

Field Organization—Gang Makeup

All trench excavation at Fort Wayne was handled by dragline machines and backfilling was done with same equipment, supplemented by a caterpillar tractor with bulldozer attachment.

No skilled labor, other than foremen and dragline operators, was required in laying pipe or making joints, nor was any mechanical equipment or supplies necessary, other than two ratchet wrenches for the bolters in each gang. Each laying gang was composed of ten men, consisting of a foreman, dragline operator and helper, grademan, two tampers, two bolters, a painter and one man to apply rings—all being common labor, except as noted. The painter and ring man also handled scraping and other miscellaneous operations, while the machine helper attached the laying sling and assisted in lowering the pipe into the trench with the dragline machine.

If the pipe had been laid with riveted joints, the number and class of men engaged in the several operations, incident to setting the pipe to grade and connecting it, would have been practically the same, except in matter of making bell holes, where additional labor is required to handle the extra excavation. However, the greatest expense would have come in the steel end, where a gang of skilled workers, consisting of foreman, six boilermakers, four helpers and one laborer must generally be furnished for each riveting gang. In addition to this, an air compressor, air hammers, air motor, air hose, portable

forge and a miscellaneous assortment of small tools would have been required with each gang. Riveting supplies include rivets, blacksmith coal, air and oxygen for heating and cutting torches, etc.

For electrically welded joints, the labor gang would have been the same as for the Dresser couplings, except for bell hole excavation. The jointing gang would have consisted of an expert welding foreman and as many certified electric welders as required to keep pace with laying progress. The number will depend upon the type of weld, whether butt strap, chill ring, V type butt weld (with or without backing and filet), or lap weld, together with number of passes required to deposit sufficient metal at the joint. In the matter of equipment, one or more portable electric welding generators would have been required. Possibly, also an air compressor for a more thorough and rapid cleaning and chipping of slag and oxidation from the bead, if more than one pass was needed to make the joint. Welding supplies consist of welding rods, as well as air and oxygen for the torches.

Progress Governed by Excavation

Trench depths, at Fort Wayne, ranged from eight to fifteen feet. In locations where the trench was not obstructed by intersecting sewers and water pipes, an average of forty-five minutes were required to excavate for and lay a 40-ft. section of pipe. This made the excavation the governing factor in general laying progress, because the placing of pipe in trench and bolting of joints were always up with the excavation.

Bell or Joint Hole Dimensions

No extra trench labor, over the usual gang makeup, was required to dig bell or joint holes, or for connecting and bolting the couplings. Since little enlargement, outside usual trench dimensions, was necessary, the grademan, assisted by the bolters, had ample time to perform this task. With Dresser type couplings, only sufficient space is required in the bell hole to allow free movement of the ratchet wrenches used for bolting. We found that bell holes should be, not less than, 10 in. deep by 24 in. long; and that skimping on bell hole size is poor economy, because doing so hampered the speed and efficiency of the workmen in the bottom of trenches eight to ten feet deep. The depth under the joint was considered far more important than the space on either side; for, due to working in cramped space and obstructed vision it is along the bottom that the preponderance of leaks generally occur with all types of joints.

It is obvious, of course, that a bell-hole for one man on each side of the pipe requires much less space than one that must provide space for buckers, riveters or welders to move freely around the pipe. By spotting bell holes ahead, the excavating machine can rough out the holes, but the actual trimming must be done with pick and shovel.

Laying Pipe

In laying operations, an outer ring, gasket and center ring were always kept in place on the free end of the last section of pipe in the trench. On the next section to be laid, an outer ring and gasket were placed on the laying or connecting end; and, an outer ring, gasket and center ring was fitted on the opposite end—all rings and gaskets being fitted while the section was still on the trench bank or ready for lowering. The contact between rings and pipe was always sufficiently tight for them to carry into the trench, without dropping off.

The tool most frequently used for applying the rings was a pointed spud bar, in the hands of one man, who used it with a small hardwood block to pry the rings

Plate 1.—The 42-inch Diameter Pipe on Curve of Radius 150 Feet. In Foreground Are Two 36-inch Valves Which Were Later Housed in Concrete Vault.

on. However, in some instances where the pipe was considerably out of round, due to distortion in transit, jacks had to be used to bring back the circular section, until an outer ring could be slipped on. The latter thereafter held the pipe in shape. A very convenient and simple tool for this purpose was a crank operated expander, loaned by the pipe manufacturer. There were cases where the expander was found to be a great time saver. The work of applying the rings was a small matter and was handled by one man in each laying gang, who also had time to scrape pipe ends, except where trenching was unusually rapid. In such cases he was given temporary assistance.

When a section of trench was ready, a length of pipe was picked up with a padded sling. This was made with a double line of steel cable, in the form of a loop, which was slipped through a piece of old fire hose. The sling was placed around the pipe at about center, to secure horizontal balancing, and then attached to the hoist line on the machine.

Sometimes, laying had to be done from the trench side, but where conditions would permit, it was preferable to lay from trench end, to avoid loss of time in machine operation due to moving between digging and laying position. From ten to fifteen minutes were consumed in laying a section from the trench side and about five minutes from the end.

After the pipe had been picked up by the crane, the free end was steadied by the grademan and machine helper, while being swung to the center line, and these men followed it down into the trench. The laying end was then taken by the bolters and guided into the center ring. In side laying, a slight swing of the boom was usually sufficient to force the pipe against the stop or center bead, while in end laying, the machine would move forward the required amount. In cases where a tight fit made entry difficult, the pipe was swung from side to side of trench and center ring lightly tapped with a sledge, until full entry was obtained. Very often, when a pipe lodged, it was held by a gasket or outer ring, which had not been pushed back far enough on the pipe, or the section was not suspended in a horizontal position and was binding inside the center ring. The solution of this slight difficulty came with practice and it

did not require much time for the laying gang to become proficient in laying the pipe and handling the couplings.

While setting a section, a man was always stationed inside the pipe at the joint to signal when both ends of the pipe were at rest against the stop, or to measure the amount of opening left between ends of pipe when deflecting for curvature. This man was usually the painter, who would immediately begin painting the interior of the joint and touching up any damaged spots in the coating, as soon as pipe was released by the crane.

This man was the only workman who needed to enter the pipe. This we considered a distinct advantage, for it reduced to a minimum, damage to the inside coating. There were no tools or equipment, such as are required for riveting or inside welding, to be taken in and out, or accidentally dropped on the coating. Inside crews were eliminated, and with them all the damage done to the coating by repeated travel back and forth over it.

After a section had been set to line and grade, the bolters, who generally were waiting for the joint, would begin work. Bolts previously distributed in kegs, were drawn for each joint. The gaskets and outer rings were moved up to the center ring, all bolts inserted through the outer rings and nuts run up by hand. Following hand tightening of bolts, ratchet wrenches were applied first at quarter points—top, bottom and sides, the two bolters working simultaneously on bolts directly opposite from each other. The usual practice was to draw first on the top and bottom bolts and then the side bolts, so that the outer rings and gaskets might uniformly move into final position. This done, the bolters would then start at the bottom of the pipe and work on opposite sides to the top—bringing all nuts, the first time over, to a firm bearing only. This operation was repeated three to four times, avoiding any great pressure on the wrenches, when bolting was considered complete. The secret of a tight joint was found to be a *moderate but uniform pressure applied at all points* around the circumference.

No other special precautions were taken to secure water tight joints, except to keep dirt, grit and foreign matter from beneath the rings and gaskets, and to be sure that the gasket's retaining rim (in the face of the outer rings) had moved over and across the edge of the center ring, all around the circumference. Wherever the outer ring lodged against the edge of the center ring, the gasket was not properly forced home and a leak occurred. In the completed Fort Wayne line, this was the sole cause of both of the two leaks found. A small paint brush, with medium stiff bristles, was very useful for cleaning the metal surfaces and removing dirt from beneath the gaskets.

The foreman, assisted by the painter, was delegated with the responsibility of inspecting all joints after bolting had been completed, to make sure that the rings and gaskets had properly entered and the bolts were at the proper tension. This inspection completed, the painter would then cover, with field coating, the exterior surface of the coupling, together with all bolts and nuts, when the joint would be complete and ready for test and backfilling.

On an average, but twenty-five to thirty minutes were consumed by the bolters in completing a joint. This left them time to bring up bolts for the next joint and remove the nuts, or to assist in cutting the bell-hole for the next joint. Power devices for running up the nuts would appear to have no advantage, because a reduction in bolting time would affect no real economy in general laying costs.

Except where obstructions interfered, such as water pipes, sewers, etc., which required time and hand labor to clear, each gang at Fort Wayne laid from eight to ten 40-ft. sections of pipe per eight-hour shift, which were coupled, completely bolted and partially backfilled, ready for test. All pipe operations were done in a leisurely manner, for there was always time available while waiting for the machine to complete excavation for the next section. If the rate of excavation could have been speeded up, the labor gang would have worked more steadily and the number of sections completed per shift could have been increased.

Something quite novel to the writer, in an experience covering a variety of pipe line projects and several methods of connecting pipe in the field, was this: When Dresser type couplings are used, the number of feet of pipe laid is the actual number of feet completed, ready for test and backfilling. There is no lag between laying and jointing. Both proceed simultaneously and there is no further pipe operations after test.

Here some comparisons might be made. Based upon experience with riveted lines, six to seven joints completed per eight-hour shift, for moderate pipe diameters, is a fair average day's work for good, careful riveting, with grit seams calked in and out, and rivets on inside only. This is the character of work that occasions least trouble and expense on test. If the laying gang is progressing at the rate of eight sections per shift, and the steel gang at six, but a few days will elapse until the laying gang is well ahead. This means extra bell-hold maintenance, unless extra steel workers are put on, which in turn requires extra compressor capacity.

Field welding varies so widely in practice and specifications that it is hard to make an estimate as to what a fair rate of progress should be. Often welding operations in the trench are slowed up by the difficulties of welding in cramped, awkward quarters. Jointing progress, however, can always be kept abreast of laying operations by employing sufficient welders and portable generators.

Due to adoption of a laying schedule which required that pipe be laid in reverse directions from two points, several closures had to be inserted in the Fort Wayne line. It was a simple matter to make such closures with center rings of couplings converted into sleeves, by burning out the stops or center beads in two center rings, and applying the rings and gaskets to the ends of the pipe at the gap and on the closure piece without more difficulty than making two regular joints. The center rings were driven back flush with the ends of the pipe. After the closure piece, cut to correct length and fitted with rings and gaskets, had been dropped into place the center rings were backdriven to an equal lap on both pipe and closure piece and thereafter handled as a jointing operation—the only difference being the missing bead from the center ring. From two to three hours was ample time to fit up and complete the average closure in this manner. In the writer's experience, full riveted closures require a part gang of boilermakers and helpers from ten to eighteen hours to complete; and, some welded closures require from five to seven hours. By comparison, the making of closures with the Dresser type of coupling was a sinecure and the writer wishes to call to the attention of the reader of this article their value and simplicity for such purposes.

Editor's Note.—We regret that the length of Mr. Curd's illuminating article make it necessary to carry the second part over to the next issue. Part II discloses methods adopted in making leakage tests and the results; describes special problems in river crossings and their solution; reveals other valuable experiences gained on the Fort Wayne project.

(To be concluded in the next issue.)

SLUDGE DEWATERING AT THE BALTIMORE SEWAGE WORKS

A Study of the Economics of Natural Drainage vs. Vacuum Filtration

By C. E. KEEFER
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C. E. Keefer

FOR more than twenty years the sludge drawn from separate digestion tanks at the Baltimore sewage works has been dewatered on sludge drying beds. During this period it is estimated that over 400,000 cu. yd. of dried material has been handled. The sludge bed area is one of the largest in the country, amounting to 578,233 sq. ft. Considerable experience and data have been collected during these years regarding sludge drying. However valuable this information is, it is believed that the experiments, which have been conducted during the past decade on the dewatering of sludge by mechanical means, are of greater importance. The significance of this statement is apparent when it is realized that experiments, which have just been completed, indicate that digested sludge can be dewatered for about $3.30 per ton of dried solids as compared with an average cost of $6.13 when drying the material on sludge beds. In view of the scope of the sludge drying problem at Baltimore and the investigations and the developments in the mechanical dewatering of sludge at the Baltimore Sewage Treatment Plant, it seems desirable to recapitulate and summarize some of the experiences and the findings of recent years.

TABLE I.—AVERAGE COST OF OPERATING SLUDGE DRYING BEDS FOR 1925-33, BALTIMORE SEWAGE WORKS

Average yearly quantity of sludge removed (cu. yd.)[1]		26,986
Moisture content (per cent)		68 7
Dry solids content (tons)		6 369
Total costs		
Interest and depreciation	$19,573	
Operating cost	19,230	
Total		$38,803
Unit costs		
Fixed cost per cu. yd.	$0.76	
Operating cost per cu. yd.	0.75	
Total		$1 51
Fixed cost per ton of dry solids	$3.08	
Operating cost per ton of dry solids	3.05	
Total		$6.13

[1]Does not include a considerable volume of lagooned sludge which never reached the sand beds.

*The author of this article is in charge of sewage treatment works design and plant operation. B. L. Crozier is Chief Engineer of Public Works, and Geo. E. Fink is Sewerage Engineer.—*Editor.*

Sand Bed Dewatering

The sludge to be dewatered is that from unheated digestion tanks. The material is not particularly easy to dry as it is not thoroughly digested. During the 8-year period from 1926 to 1933, inclusive, the volatile matter in the sludge has varied from a yearly average of 58.0 to 68.0 per cent with an 8-year average of 63.1 per cent. The material would have dried much quicker if the volatile matter had been below 55 per cent. Consequently, the frequency with which the beds were cleaned was less than would normally be the case, the average being 3.94 times a year.

One factor that has increased the cost of sludge drying has been the lack of sufficient sludge beds. As indicated by Table I, the average moisture in the sludge cake removed during the past 9-year period has amounted to 68.7 per cent. The operating cost of removing this material averaged 75 cents per cu. yd., or $3.05 per ton of dry solids. It was necessary to remove the cake before it had thoroughly dried in order to draw more wet sludge from the digestion tanks to the beds and thereby provide space in the tanks for additional raw sludge. If a larger drying area had been available, the sludge could have been retained on the beds for a longer time so that a drier cake could have been removed at less expense of handling. On the other hand, the fixed charges would have been higher because of the investment in and upkeep of additional sludge beds.

In this connection the cost of the sludge beds is of interest. These costs, as indicated by Table II, have varied from 21 to 81 cents per sq. ft. One of the reasons for the low cost of beds 5 and 6 is that they were constructed in 1914-15, when prices were comparatively low. The cost of building beds 11 to 14, inclusive, was high because of the large amount of excavation involved. Experience indicates that sludge beds can be built in Baltimore under normal conditions for from 40 to 50 cents per sq. ft.

TABLE II.—COST OF SLUDGE DRYING BEDS, BALTIMORE SEWAGE WORKS

Bed No.	Date Built	Area Sq. Ft.	Cost Total	Cost Per Sq. Ft.
1-2	1923-24	90,000	$ 36,079	$0.40
3-4	1922-24	90,000	35,171	0.39
5-6	1914-15	138,223	28,935	0 21
7-8	1922-23	100,000	54,670	0.55
11-14	1926-27	160,000	129,258	0.81[1]

[1]Cost high because of considerable excavation.

Experiments With Centrifuge

One of the first experiments[1] that was conducted at Baltimore on the mechanical dewatering of sludge was with a centrifuge, which was made in Germany. This

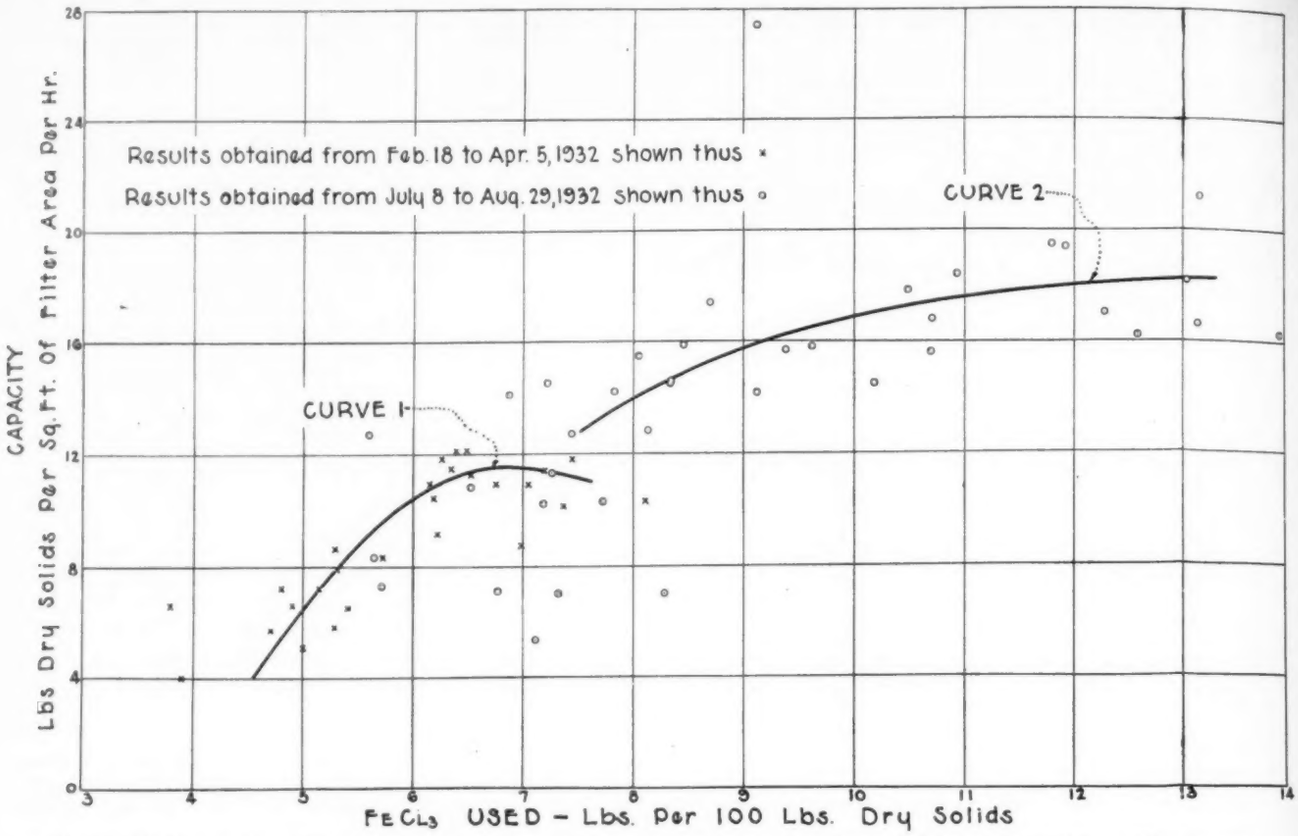

Fig. 1.—Yields of Oliver Vacuum Filter—Digested Sludges Coagulated with Ferric-Chloride—(1) Winter; (2) Summer.

machine was designed to operate continuously at a speed of 1,200 r.p.m. A cake output, containing about 480 lb. of dry solids an hour, was obtained with a moisture content of approximately 71 per cent. The total cost of dewatering was estimated to be about $7.10 per ton of dry solids. One of the great drawbacks to the centrifuge was the dirty character of the effluent, which had a 5-day B.O.D. of 9,100 p.p.m. Furthermore, about 35 per cent of the solids, which entered the machine, passed off with this effluent and had to be treated. The sludge which was centrifuged, like much of the sludge dewatered on the beds, not thoroughly digested and contained about 68.6 per cent volatile matter; whereas, well digested sludge when obtained at the Baltimore sewage works contains from 50 to 55 per cent volatile solids. Moreover, no coagulants were used to condition the sludge and the results obtained indicated the desirability of making further experiments on centrifugal dewatering.

Sludge Filtration

An investigation that proved more promising than centrifuging consisted of a series of experiments[2] conducted in 1931 and 1932 with two small vacuum filters. One was a product of the Bartlett-Hayward Co. (the Genter filter) and the other was supplied by the Oliver United Filters, Inc. Digested sludge (51.5 to 61.1 per cent volatile matter) was dewatered and ferric-chloride or "chlorinated-copperas" were used as coagulants. A long series of tests, some of which lasted for 14 hrs., were made. From the data obtained it was possible to correlate the capacity of the filter with the quantity of coagulant used, the filter yields increasing with larger dosages of chemicals within limits, and thereafter gaining no further or showing a diminishing yield. Figure 1 shows the filter capacity when using various quantities of ferric-chloride. Two independent groups of experiments were made, the results of the summer and winter tests shown by the two curves. The results obtained from Feb. 18 to April 5, 1932, are indicated by curve 1, and those from July 8 to Aug. 29, 1932, are shown by curve 2. During the winter period higher capacities were obtained with the use of smaller quantities of coagulant than during the summer period. In the latter period it was impossible to obtain a satisfactory filter cake with the use of less than about 7 lb. of ferric chloride per 100 lb. of dry solids.

At the time these experiments were made there was no satisfactory explanation for the observation that the sludge removed from the sewage in summer was harder to filter than that obtained in winter. Subsequent experiments, conducted by Genter,[3] indicated why more coagulant is needed at one time than another. A discussion of his work will be given later.

Although it was shown by Mohlman and Palmer[4] that "chlorinated copperas" was not so effective a coagulant as ferric chloride, it was decided to experiment with the former chemical as copperas and chlorine can be purchased at a low price in Baltimore. A total of 16 tests were made to determine the rate of filtration when coagulating digested sludge with various quantities of "chlorinated copperas." Each of these tests lasted in most cases for 1 hr. The capacities that were obtained are shown in Fig. 2. When using 10 lb. of "chlorinated copperas" (computed as $FeSO_4Cl$) per 100 lb. of dry solids in the sludge, a cake output containing 7.0 lb. of dry solids per square foot of filter area per hour was obtained. When either ferric chloride or "chlorinated copperas" was used, the average moisture of the cake was slightly less than 75 per cent.

Cost estimates have been prepared on the filtering of the digested sludge produced at Baltimore when using ferric chloride and "chlorinated-copperas" as coagulants. The basic data used in preparing these estimates are

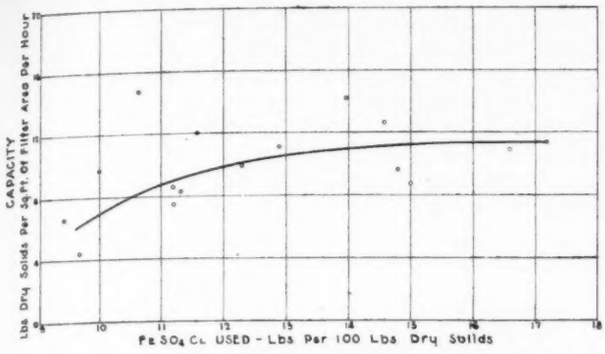

Fig. 2.—Yields of Oliver Vacuum Filter—Digested Sludges Coagulated with "Chlorinated-Copperas"—Computed as $FeSO_4$:Cl.

given in Table III. It has been assumed that four 350-sq. ft. filters, operating 7¾ hr. daily for 300 days a year would be needed to dewater 182,400 tons of wet sludge yearly. The estimated cost per ton of dry solids when using ferric chloride is $4.38 in winter. When using "chlorinated copperas," the filtration cost is $4.66 in summer.

The experiments indicated that by using large quantities of coagulant the filter capacities could be greatly increased, and the size of the filter installation could be made smaller. On the other hand, it is much more desirable to provide a large filter installation and use as small a quantity of coagulant as possible as the total cost of filtration will be much less.

Filtering Elutriated Sludge

The foregoing experiments indicated the desirability of using filters to dewater the sludge at Baltimore. The process is independent of weather conditions; a very small space is required for the filtering equipment; and the drying operations can be carried on 24 hrs. a day for 365 days a year if so desired with the result that provision for sludge storage is not necessary in winter. Most important of all, the process is considerably cheaper than drying sludge on sand beds.

TABLE III.—ESTIMATED COST OF FILTERING DIGESTED SLUDGE, BALTIMORE SEWAGE WORKS

	Sludge Unelutriated		Sludge Elutriated	
	Using Ferric Chloride	Using Chlorinated Copperas	Using Ferric Chloride	Using Chlorinated Copperas
Quantity of coagulant (anhydrous) used per 100 lb. of dry solids	5.25 lb.[1]	11.00 lb.[2]	2.50 lb.	4.10 lb.
Dry solids in cake per sq. ft. of filter area per hr.	6.84 lb.	7.92 lb.	7.20 lb.	7.00 lb.
Installation cost of filter plant	$120,000	$125,000	$139,000	$144,000
Fixed costs	$11,423	$12,058	$12,390	$13,026
Operating costs	$36,577	$38,942	$24,610	$22,874
Fixed and operating costs	$48,000	$51,000	$37,000	$35,900
Cost per ton of dry solids	$4.38	$4.66	$3.38	$3.28

[1] Quantity of coagulant used based on filtering sludge obtained in winter.

[2] Quantity of coagulant used based on filtering sludge obtained in summer.

Number of persons served.....790,000
Sewage flow .....60 m. g. d.
Wet sludge to be filtered daily.....608 tons
Dry solids in cake produced daily.....36.5 tons
Operating schedule .....7¾ hr. daily, 300 days a year
Number of filters.....4
Effective area of each filter.....350 sq. ft.
Cost of ferric chloride.....$44.00 a ton
Cost of chlorinated copperas*.....$22.78 a ton*

*Cost of chlorine and ferrous sulphate—8 pounds of copperas ($FeSO_4:7H_2O$) requiring 1 pound of chlorine to produce 5.36 pounds of anhydrous "chlorinated-copperas," expressed as ($FeSO_4$.Cl).

The cost of coagulant to be required represented more than half the total cost of the process. It, therefore, seemed desirable to continue the laboratory and field experiments in order to find some way of reducing the amount of coagulant required. Investigations, conducted by A. L. Genter, consulting chemical engineer, in the laboratories of the Baltimore sewage works, indicated that the concentration of soluble ammonia derivatives and ammonium compounds had a decided bearing on the quantity of coagulant needed to flocculate sewage sludge. Under normal conditions when a coagulant such as ferric chloride is added to sludge, the effectiveness of a portion of the chemical is lost as it enters into chemical combination with the ammonium compounds. Such an effect is commonly known as a buffering effect. The major portion of these compounds can be removed by elutriating the sludge with water. The elutriation process consists of thoroughly mixing water or sewage effluent with the sludge to be filtered. The mixture is allowed to stand for several hours so that the sludge can settle. A considerable portion of the ammonia derivatives and ammonia compounds diffuse into the water. The supernatant is then decanted, and the sludge is ready to be coagulated and filtered. Within limitations, the greater the quantity of elutriating water used, the greater will be the removal of ammonium compounds and the less will be the quantity of coagulant required.

Fresh sludge usually contains considerable quantities of nitrogenous compounds, which decompose into amides, amines, amino acids and eventually into ammonium carbonate and bicarbonate. The quantity of soluble amino acids and ammoniacal compounds are indicated by the concentration of nitrogen, which is referred to as amino-ammonia nitrogen in this article. The amount of amino ammonia nitrogen in fresh sludge usually varies from about 50 to 100 p.p.m. As the material decomposes, the concentration increases and when digestion is about complete it ranges from 700 to 1,000 p.p.m. and even higher. By elutriating one volume of sludge with 2 volumes of water the amino ammonia nitrogen can be reduced by about 55 per cent and by using 4 volumes of water the reduction will be approximately 70 per cent.

A long series of experiments[5] were conducted in order to determine the effect of elutriation of digested and partially digested sludges on the quantity of cake that can be produced when using different coagulants and varying amounts of the same coagulant. Furthermore, the effect of the concentration of the solids in the wet sludge on the filter capacity was studied. The filtration of unelutriated and elutriated raw sludge also was investigated. All of these experiments were made with an Oliver filter having a working area of 18 sq. ft.

The effect on filter yields by elutriating digested sludge with 1, 2 and 3 volumes of water is shown in Fig. 3. The unelutriated sludge contained 6.0 per cent solids with an amino ammonia nitrogen content of 736 p.p.m. A portion of this material was coagulated with various quantities of ferric chloride and filtered. The results are indicated by the curve marked "Unelutriated sludge —Not thickened." Some of the sludge was thickened by settling it over night so that the solid content had increased to between 6.5 and 6.7 per cent. When using less than 8.2 lb. of ferric chloride per 100 lb. of dry solids, there was a slight increase in the filter capacity.

Another portion of the sludge was elutriated with one

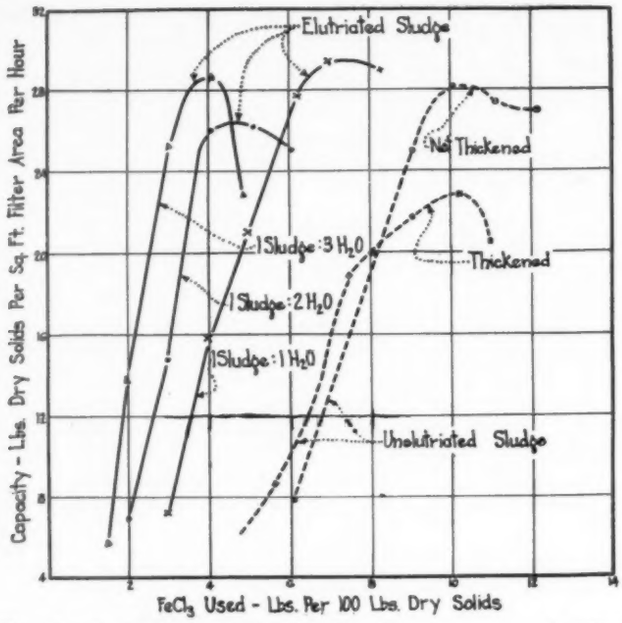
Elutriated Sludge
Not Thickened
1 Sludge : 3 H_2O
Thickened
1 Sludge : 2 H_2O
1 Sludge : 1 H_2O
Unelutriated Sludge
Capacity - Lbs. Dry Solids Per Sq. Ft. Filter Area Per Hour
$FeCl_3$ Used - Lbs. Per 100 Lbs. Dry Solids

Fig. 3.—Comparing Ferric-Chloride Requirement and Filter Yields—Sludge Elutriated with Varying Volumes of Water vs. Non Elutriated Sludge.

volume of water so that the amino ammonia nitrogen content was reduced to 440 p.p.m. A considerable increase in filter capacity resulted. With the use of 6.0 lb. of ferric chloride per 100 lb. of dry solids, there was a cake output of 7.6 lb. of dry solids per square foot of filter area per hour when filtering unelutriated sludge. This output was increased to 26.6 lb. (350 per cent increase) when the sludge was elutriated with one volume of water. When 2 and 3 parts of elutriating water were used, the amino ammonia nitrogen was reduced to 294 and 168 p.p.m. respectively with further increases in the filter yield.

Another interesting group of experiments consisted of studying the increase in the filter capacity as the amino ammonia nitrogen was gradually reduced by elutriating the sludge with more and more water. The results of these studies are shown in Fig. 4. The amino ammonia nitrogen was reduced in successive steps from 800 p.p.m. in the unelutriated material to 95 p.p.m. with a considerable progressive saving of coagulant. For example, 7.2 lb. of ferric chloride per 100 lb. of dry solids was required to produce a cake containing 8 lb. of dry solids per square foot of filter area per hour when filtering unelutriated sludge. After reducing the amino ammonia nitrogen content by elutriation to 95 p.p.m., 1.3 lb. of ferric chloride produced this same capacity, representing a reduction of 82 per cent in the quantity of coagulant used. The decrease in the amino ammonia nitrogen content was 88 per cent.

Numerous experiments were made to determine the relative value of ferric chloride, "chlorinated-copperas," "Calcoag" and "Ferrisul" (both of the latter being ferric sulphates) when used as coagulants prior to filtration. Ferric chloride gave the highest yields whether unelutriated or elutriated sludges were filtered. The next best results were obtained with "chlorinated copperas."

Several experiments were conducted to study the effect of elutriation on the filtering of raw sludge. The results of this work are shown in Fig. 5. First unelutriated sludge was dewatered. Then another portion of the material was elutriated with two volumes of water and filtered. The increase in capacity caused by elutriation was not so striking as in the case of digested sludge primarily because the raw sludge had a low amino ammonia nitrogen content (220 to 344 p.p.m.) and elutriating this material with two volumes of water only reduced this concentration to 134 p.p.m. The use of 0.8 lb. of anhydrous ferric chloride per 100 lb. of dry solids gave a yield of 4.2 lb. of dry solids per square foot of filter area per hour when dewatering the elutriated crude sludge. To produce the same output when filtering unelutriated sludge, 2.4 lb. of anhydrous ferric chloride was required.

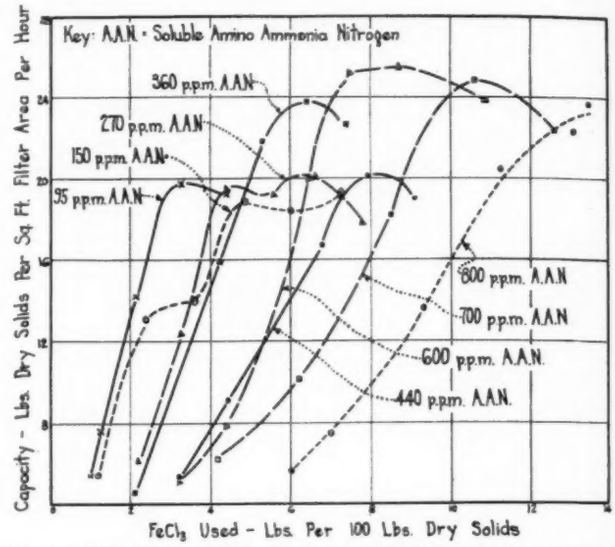
Key: A.A.N. - Soluble Amino Ammonia Nitrogen
360 p.p.m. A.A.N.
270 p.p.m. A.A.N.
150 p.p.m. A.A.N.
95 p.p.m. A.A.N.
800 p.p.m. A.A.N.
700 p.p.m. A.A.N.
600 p.p.m. A.A.N.
440 p.p.m. A.A.N.
Capacity - Lbs. Dry Solids Per Sq. Ft. Filter Area Per Hour
$FeCl_3$ Used - Lbs. Per 100 Lbs. Dry Solids

Fig. 4.—The Effect of Elutriation in Reducing Amino-Ammonia Nitrogen by Progressive Sludge Washings—Note progressive reduction in Ferric-Chloride required to give specific filter yields.

Elutriating Water

In elutriation the volume and the strength of the decanted wash-water is such that the disposal of the liquid in comparatively simple. In order to elutriate the digested sludge at Baltimore (about 608 tons of wet material per 24 hr.) with two volumes of water, 292,000 gal. of elutriate would have to be disposed of daily. This volume is less than 0.5 per cent of the sewage flow. An average of several tests indicated that the elutriate had a 5-day B.O.D. of 158 p.p.m. and contained 270 p.p.m. of suspended solids. It is planned therefore to add this liquid to the raw sewage.

Cost of Filtering Elutriated Sludge

The costs of filtering elutriated sludge coagulated with ferric chloride and with "chlorinated-copperas" are given in Table III. When using ferric chloride, it is estimated that 2.5 lb. will be used per 100 lb. of dry solids in the sludge with a cake production containing 7.2 lb.

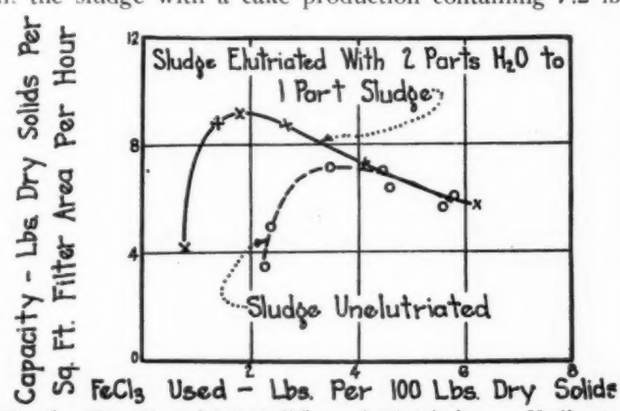
Sludge Elutriated With 2 Parts H_2O to 1 Part Sludge
Sludge Unelutriated
Capacity - Lbs. Dry Solids Per Sq. Ft. Filter Area Per Hour
$FeCl_3$ Used - Lbs. Per 100 Lbs. Dry Solids

Fig. 5.—The More Limited Effect of Elutriation on Undigested (fresh) Sludge—Which Contains Less Water Soluble Nitrogen Compounds. Compare with Fig. 4 for digested sludges.

of dry solids per square foot of filter area per hour. The installation costs, which are estimated to be $139,000, include 4 350-sq. fit. filters, a building for housing the equipment, 4 elutriating tanks with a total capacity of 58,200 cu. ft. and other miscellaneous appliances. The estimated yearly cost of dewatering the elutriated sludge containing 10,950 tons of dry solids is estimated to be $37,000, including all charges, or $3.38 per ton of dry solids.

When "chlorinated copperas" is used as a coagulant, it is estimated that 4.1 lb. will be needed per 100 lb. of dry solids in the sludge with a cake production containing 7.0 lb. of dry solids per square foot of filter area per hour. The total cost of the filter installation including 4 350-sq. fit filters and chlorinating equipment is estimated to be $144,000. The total cost of filtering the sludge is estimated to be $35,900, including fixed charges, or $3.28 per ton of dry solids.

Conclusions

It is apparent that the vacuum filtration of digested sludge is a marked advance over air-drying methods in so far as the operation at Baltimore is concerned. The filtering of unelutriated sludge at an average cost of about $4.50 per ton of dry solids is about 26 per cent cheaper than when the sludge is air-dried at an expenditure of $6.13 per ton. By elutriating the sludge the amount of coagulants used is greatly reduced so that the filtration cost is only about $3.30 per ton, or a reduction in cost as compared with air-drying methods of about 46 per cent. In preparing these estimates no credit has been given mechanical filtration to compensate for the fact that sludge storage space is not required to take care of winter conditions whereas such must be provided when sludge bed drying is relied upon.

Up to the present time it has general been felt that vacuum filters are more applicable at large sewage works. At small plants where not a great deal of coagulant is used, the bed dewatering of sludge, with or without coagulants, is likely to be cheaper. However, by elutriating the sludge, the cost of dewatering can be considerably reduced and thereby mechanical filters stand a better chance of becoming economically feasible at smaller sewage works.

The Baltimore sewage works is under the general supervision of B. L. Crozier, chief engineer, Department of Public Works, and George E. Finck, sewerage engineer. G. K. Armeling is superintendent of the sewage treatment works, and Edward Cromwell is principal sanitary chemist.

Acknowledgment.—The graphs used in illustrating this article are in part the same that were used in references 2 and 4 below and are reproduced with the consent of Sewage Works Journal.

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Richmond Feeds Powdered Carbon Through White Dry Feeders, "Believe It—or Not"

At the Richmond, Va., Filtration Plant powdered activated carbon (Nuchar) is fed through dry feed machines which are, like all others in the plant, painted white. And, they stay white! How is it possible? Ask M. C. Smith, Water Supply Engineer and C. F. Bingham, Filtration Supt. at Richmond. It wasn't simple until experimentation revealed to them how to obtain dustless operation.

The carbon is applied direct from the feeders at a rapid rate, of short duration, to the filters after each wash. The application is made as one batch operation during filling of the unit following the wash and the carbon then settles gently onto and into the sand surface. The rate of application is three (3) pounds of carbon per million gallons of filter capacity (9 lbs. to each 3 m.g.d. unit). The dosage is completed within a few minutes, the dry feed machine discharge passing to a 1½ inch copper distributing manifold delivering to the filters. This single carbon dosage ordinarly suffices for the complete run of the filters but is repeated when taste and odor tests on influent and effluent indicates it to be required. The method of treatment is inexpensive and effective for moderate taste troubles but not sufficient for removing pronounced tastes without supplementary treatment at the filters or prior thereto. The batch scheme serves an excellent purpose of promptly building up a taste absorption "reservoir" in each newly washed filter. The economy of the method is its oustanding feature.

Canajoharie Wastes Disposal Plant Goes Into Operation

Public inspection and dedication of the Canajoharie (N. Y.) Combination Wastes Disposal Plant was held December 15th. The unique feature of the plant is that it combines sewage treatment, garbage and rubbish incineration in a single plant. The heat from the incinerator is used to warm the sludge digestion tank and heat the building; and, the sludge gas is burned as auxiliary fuel in the incinerator, resulting in an interesting cycle of heat interchange.

This plant which cost approximately $55,000 (complete) represents one of the earliest P. W. A. projects to be put under construction in the state. About 100 nonresident guests attended the official dedication exercises and inspected the plant in operation. This project will be described in a later issue of WATER WORKS AND SEWERAGE by Henry W. Taylor, Cons. Engr., of New York City, who is responsible for the design of this novel combination plant.

New Wastes Disposal Plant of Canajoharie

DETERMINATION OF DETERIORATION OF MAINS IN DISTRIBUTION SYSTEMS

By JOHN A. CAROLLO*

The Author

DISTRIBUTION mains represent a large proportion of water utility investments and their physical condition is a vital factor in the determination of a value in connection with rate investigations or the purchase of properties. It is also a factor to be considered in the operation of a water works, in that a study of the operating costs might show that proper water treatment may be economically balanced against excessive pumping charges. Also, the selection of pipe and its outside treatment should be given considerable study in order to govern future installations so that maintenance cost may be reduced to a minimum.

This paper describes a method of determining the condition of water distribution mains, which we have found simple of application and accurate. Testimony in arriving at values of distribution mains that begins with—"From the many years of my experience, etc.," is based on approximate knowledge and guesswork and is insufficient. The method outlined herein can be rapidly applied and results obtained over a very large proportion of the entire system without interference to service or costly connections or excavations. And, without expert experience.

As is well known, deterioration occurs simultaneously on the inner and outer surfaces of a pipe from various causes. Soil conditions may be such that pipe is impaired more rapidly from the outside than the inside. On the other hand, certain waters may corrode a pipe, others build up biochemical deposits, and still others may produce calcareous accretions. A study of both the inside and outside conditions of the different kinds, ages and sizes of pipe in a distribution system must be made to establish the over-all condition of the system.

Exterior Corrosion

The pipe condition outside is found by uncovering many different kinds, sizes and ages of pipe, cleaning thoroughly for a uniform length and measuring a number of pit depths well distributed around the pipe. Pits are measured to five-thousandths of an inch. If this procedure is followed carefully a curve can be drawn representing the rate of outside deterioration for the same kind of pipe under similar conditions.

On Fig. 1, are plotted data obtained recently by this method. The protective effect of dipping Cast Iron pipe is shown in that the rate of deterioration is much less for about the first eight years than thereafter. Whether or not the building up of a rust coat would eventually slow up deterioration cannot be definitely stated for Cast Iron pipe from these data. However, extending the curve for four inch spun Cast Iron pipe (150 lb.) would indicate a life of fifty-five years, while four inch Cast Iron Class B pipe would have a much longer life.

Numerous inspections of 2 inch black steel pipe, from twenty-three to twenty-seven years old, indicated that this kind of pipe rusted completely through in twenty-five years. Inspection of several lengths of four inch casing twenty-two years old showed numerous pin-hole leaks upon cleaning. It is interesting to note that the ratio of the four inch casing thickness to the thickness of two inch black pipe, or 138/154, multiplied by the life of the smaller pipe, which was found to be twenty-five years, equals 22.5 years. Thus is indicated a uniform rate of deterioration for ordinary steel pipe. The metal in black pipe rusted at an average rate of 0.00616 inches per year.

Interior Depreciation

Frequently the most important item influencing the value of a distribution system is the inside condition of the mains because of its direct influence on capacity. The capacity of a water main is given by:

"Q" equals AV
And: "A" equals CR^xS^y
Where: "Q" is the volume per unit of time
"A" is the area of pipe
"V" is the velocity of flow
"C" is the friction factor
"R" is the hydraulic radius
"S" is the hydraulic slope
"x" and "y" are coefficients.

This is the well-known Chesy formula for flow of water in conduits.

It is evident that the capacity of a pipe is directly proportional to the friction factor—"C." Carrying water is the function of water mains, therefore, any method that determines "C" for a main as compared to new pipe establishes the inside condition or carrying capacity of this main.

The factors necessary to determine "C" for any length of isolated pipe are:

(1) The quantity of water flowing; (2) The length of pipe; (3) The loss of pressure in this length; (4) The difference in elevation in this length.

The procedure is, briefly, to select a length of pipe of known size, age and kind and with a fire plug near the far end and valves at both ends, set pressure gauges on service connections between the plug and near valve, shut all valves, including side connection, and test for leakage, open entrance valve and fire plug, read pressure gauges, measure flow of water and determine length and

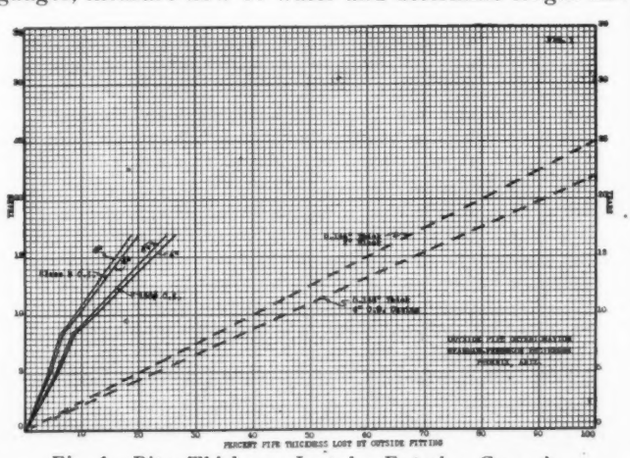
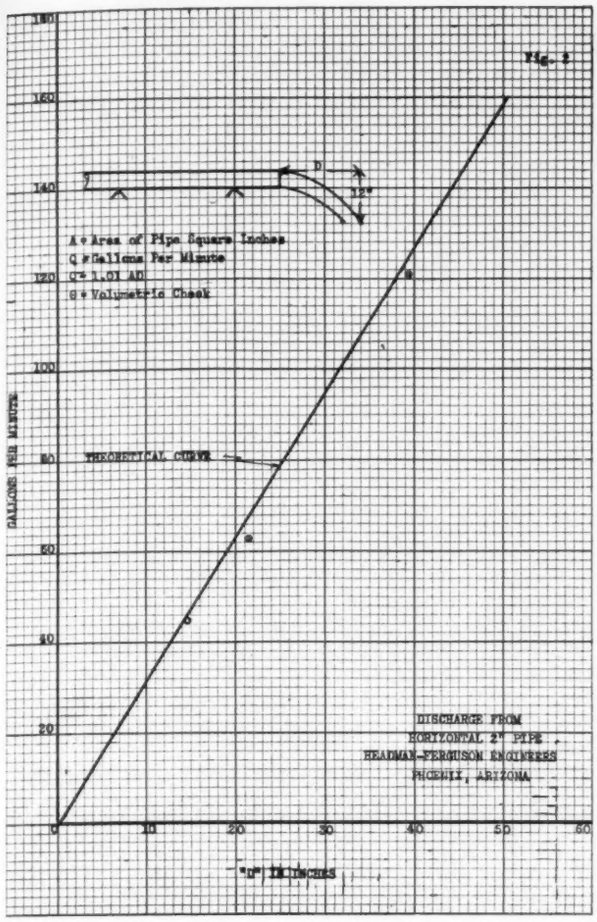


Fig. 1—Pipe Thickness Lost by Exterior Corrosion.

*Of Headman-Fergusson, Engineers, Phoenix, Ariz.



elevation difference between gauges. The information obtained is sufficient to determine "C" for the particular length of pipe considered. Several different rates of flow should be used, regulated by the plug, and variations in pressure due to use of water in other sections avoided. The equipment necessary is shown in the accompanying photograph. (See Pl. 1.)

The flow may be measured by connecting a pipe to a fire plug, leveling the pipe and measuring the horizontal distance that the stream shoots out of the pipe while falling one foot. The flow in g.p.m. is given by the formula:

"Q" equals 1.015 AD

Where: "A" is the area of pipe in square inches, and
"D" is the horizontal distance in inches.

Figure 2 is a plot of this equation for a two inch measuring pipe. The points shown are actual volumetric checks made by measuring the pipe discharge in a large tank. The accuracy of the flow measurements are well within the limits of the problem, provided care is taken to eliminate wind spray. The pressure gauges should read to half a pound and *must be calibrated frequently.*

Application of the Test Procedure

The values of "C" for Cast Iron pipe from one to thirty years old determined from actual measurements of about 16,500 feet of pipe in an Arizona town are plotted in Figure 3. Here the water supply conditions are ideal for the growth of Crenothrix, resulting in rapid tuberculation and lowering the value of "C." Visual observation of the inside of the pipes confirmed this opinion.

The problem remaining is to determine the value of "C" for new well laid pipe in the distribution system. A study of the coefficient obtained from recently laid

Plate I—A Set-Up of Equipment Used in Testing for Friction Loss and Value of "C" in Sections of Water Main.

pipe in the town in question coupled with the available literature on the subject will lead to a reasonable answer.

After the above studies have been made all pipe of the same age, kind and in the same type of soil can be evaluated on a per cent condition inside and out. The lower per cent will, of course, govern. Our study in the above town brought out that steel pipe, less than two inches in diameter, rusted through from the outside faster than it deteriorated from the inside. On the other hand, the capacity of Cast Iron pipe four to ten inches in diameter diminished much more rapidly from interior tuberculation than the metal was attacked from the outside.

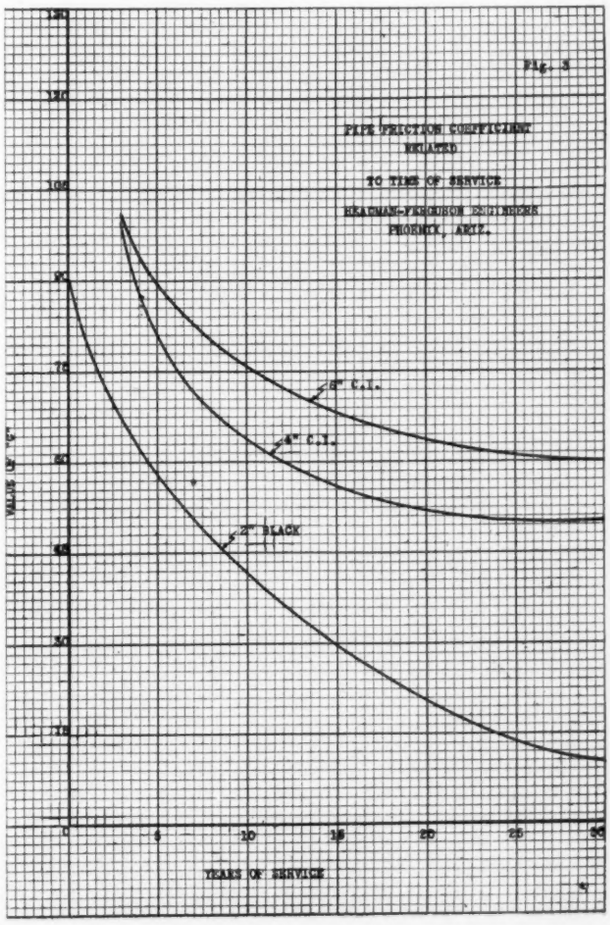
Summation

(1) This method substitutes facts for opinion in the determination of the condition of existing water mains.

(2) It is easily applied and reasonably accurate.

(3) It is evident that the applications of this method are manifold.

Acknowledgment: The above paper was presented before the Water and Sewage Section of the Arizona Public Health Association.



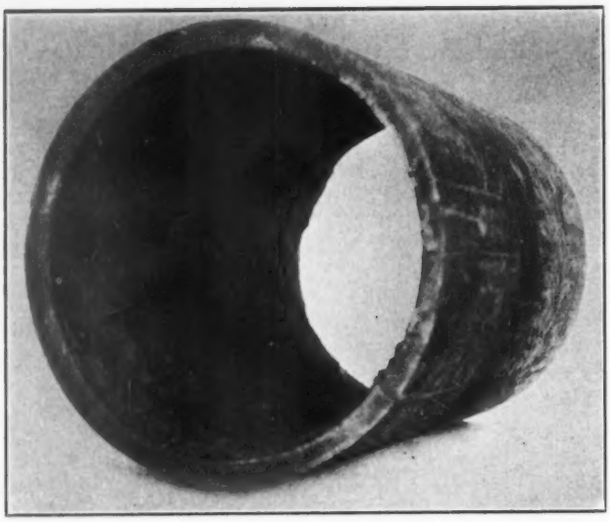


Plate 4—Section of 6 Inch, 28 Year Old Cast Iron Water Main. H & W "C" = 57.8.

EVALUATING THE DETERIORATION OF MAINS IN THE TUCSON DISTRIBUTION SYSTEM

A Discussion of the Preceding Paper by John A. Carollo

By L. R. BURCH*

Tucson Water Department
Tucson, Ariz.

IN the preceding article, are described methods for determining both the outside and the inside deterioration of water mains. Our problem in Tucson is almost entirely concerned with inside deterioration since soil conditions are such that the outside surface of cast iron pipe is almost unaffected by age. We have uncovered sections of pipe laid before 1900 and found the original coating still in good condition. Unfortunately, this is not true of the inner surface, for, although the water is not aggressive to the extent that the pipe is actually corroded, a very rough incrustation is built up, which seriously decreases the carrying capacity of the mains.

The results we have obtained after making a number of flow tests have shown the truth of Mr. Carollo's statement that any assumption based on guess-work or approximation is likely to be far from correct. Even a close examination of the inside surface of a pipe may not lead to an accurate estimate of its carrying capacity. Since the main purpose of a distribution system is to supply water at adequate pressure, and the only advantage of a larger main over a small one is its greater carrying capacity at a given pressure loss, it is evidently very important to know the relationship between the size of pipe, the rate of flow, and the loss of head. This factor is most easily expressed by some form of coefficient in one of the standard pipe-friction formulas. Probably the simplest and most accurate method of determining the coefficient is by making a flow test along the lines suggested by Mr. Carollo.

The method we have been using for testing pipe lines in the city of Tucson is identical to Mr. Carollo's method except in the measurement of the rate of flow. Mr. Carollo makes use of the laws of freely falling bodies.

*Office Engineer.

Plate 1—Calibrating Fire Hydrant at Tucson.

By measuring the horizontal distance to the jet at a drop of 12 in. from the end of the pipe, he is measuring the distance traveled by the stream in approximately one-quarter of a second, and is thus able to determine the velocity of the stream and the rate of flow in the

Plate 3—Testing Water Main for Losses.

pipe. His constant of 1.015 is equivalent to a discharge coefficient of 0.9767.

Method Employed in Tucson

Instead of attching a pipe to the hydrant and measuring the path of the jet, our method is to attach a combination mercury U-tube and pressure gauge to the hydrant and measure the residual pressure head while water is flowing from one of the 2½ inch hydrant nozzles. The U-tube is used for measuring pressures below the accurate range of the pressure gauge. This method is based on the theory of the orifice meter, since the water is caused to flow through a restricted opening and the differential pressure is measured, which in this case amounts to the gauge pressure in the body of the hydrant.

After a long series of calibration tests against standardized water meters, with flows varied from 100 to 850 fallons per minute, it was found that the velocity is exactly proportional to the square root of the residual pressure, and that the coefficient of discharge for this particular type of fire hydrant is 0.7915. All constants were then combined in the working formula, which is: G. P. M. $= 97.3 \sqrt{H}$; where H is the residual head in feet of water above the center of the 2½ in. nozzle. The whole series of calibration tests showed an average deviation from the derived formula of less than 1.1 per cent. This is well within the limits of accuracy of other measurements made during actual flow tests of mains. The method of calibrating the hydrant is shown in the accompanying photographs.

In making the flow tests, we have found that consistent results can be expected if measurements are made when the velocity in the pipe is 2 ft. per second, and greater accuracy is obtained when the velocity lies between 3 and 7 ft. per second. This means that, when testing a 6 in. main, the flow should be varied between 250 and 600 g.p.m. In order to reach this rate of flow, we do not attempt to test more than 2,000 ft. of 6 in. pipe at one set-up, and obtain better results if the total length is about 1,000 ft. Of course, when working with larger mains, the length of the section tested should be increased approximately as the cross sectional area of the pipe.

Our experience has shown that accurate results can be obtained by using three ordinary pressure gauges which have been calibrated against a master gauge. The hydraulic gradient is determined at three to five rates of flow, and several sets of gauge readings are taken at static conditions in order to check the leakage or usage in the pipe, the correctness of the elevations, and the accuracy of the pressure gauges. The actual test requires the time of four men for about an hour, and all leveling, testing of valves and calculating of results can

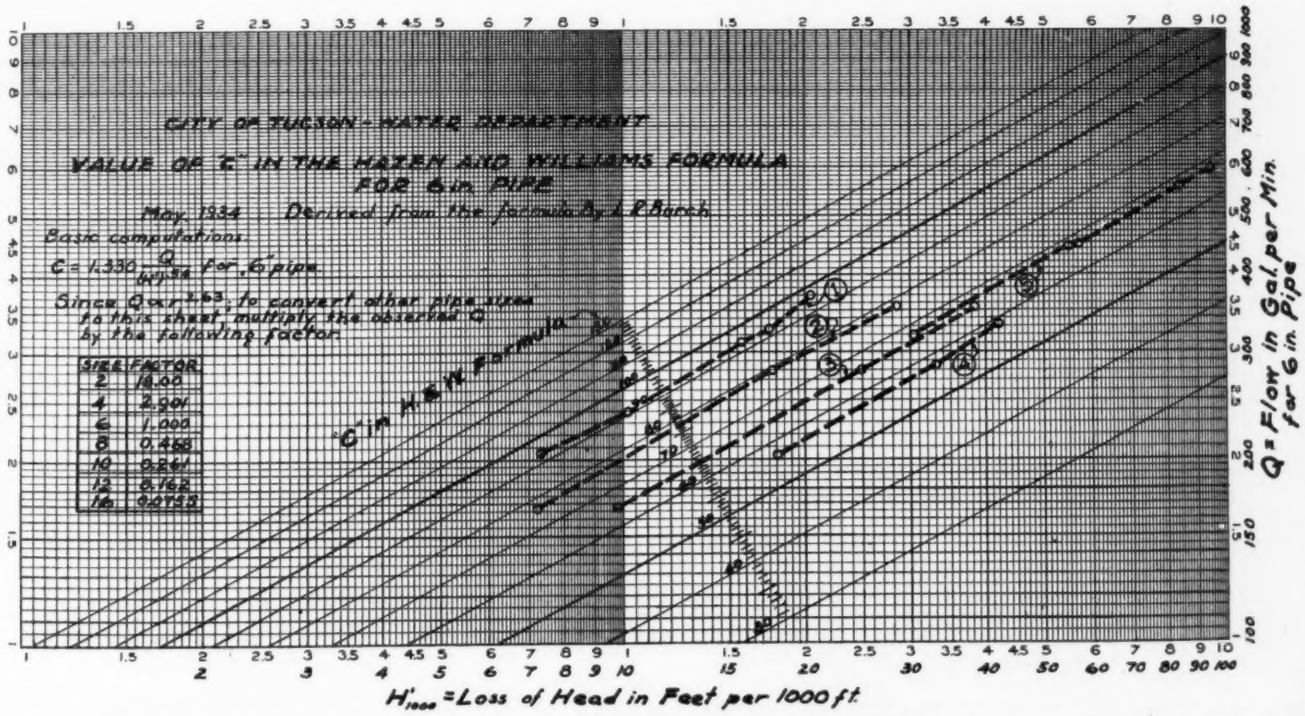

CITY OF TUCSON - WATER DEPARTMENT
VALUE OF "C" IN THE HAZEN AND WILLIAMS FORMULA
FOR 6 in. PIPE
May, 1934 Derived from the formula by J. R. Bosch
Basic computations:
C = 1.330 Q / (d^2.63 s^.54) for 6 pipe.
Since Q x d^2.63 is to convert other pipe sizes to this sheet, multiply the observed Q by the following factor:
SIZE | FACTOR
2 | 18.00
4 | 2.90
6 | 1.000
8 | 0.468
10 | 0.261
12 | 0.162
16 | 0.0758
"C" in H = 97.3 √H
Q = Flow in Gal. per Min. for 6 in. Pipe
H'1000 = Loss of Head in Feet per 1000 ft.

Fig. 1—Value of "C" for 6 Inch Pipe at Tucson, Ariz. Numbers in Circle Indicate Different Sections of Main.. The Effect of Two Different Waters Is Noted.

easily be completed in a single day. The speed of the work is increased by the use of mimeographed forms and a standard procedure for calculating the data.

We express all results by the value of "C" in the Hazen-Williams formula. This differs from the Chezy and other formulas only in the value of the exponents of the hydraulic radius and the hydraulic slope. With the pipe sizes and rates of flow found in the average distribution system, the Hazen-Williams "C" for any particular pipe is considerably higher than the corresponding Chezy "C." Our results seem to agree more closely with the Hazen-Williams formula than with any of the other commonly used pipe friction formulas. In most of our flow tests, the average amount by which any determination of the coefficient differs from the mean value is about 1.2 per cent, when calculated by the formula of Hazen and Williams, and 2.5 per cent when the Chezy or the Manning formula is used. Of course, the number of tests made is insufficient and the equipment used is not accurate enough to definitely state which exponent of hydraulic slope is in closest agreement with actual conditions. As a matter of practical consideration, the exact value of the exponents is not nearly as important as the selection of the proper coefficient.

For comparative purposes, all results are plotted on a standard logarithmic chart which was derived from the Hazen-Williams formula. This chart determines the value of "C" from the loss of head and rate of flow, and also shows up any inconsistent result, since all points plotted from each flow test should fall on the same straight line.

For comparison with Mr. Carollo's results, I have plotted the value of the Hazen-Williams "C" in a group of flow tests recently made on 6-in. cast iron mains which have been in service from 2¾ to 28 years. The apparent lack of correlation between the age of the pipe and the value of "C" is explained by the fact that two entirely different types of water are pumped into the distribution system at separate points. The South Side supply is a fairly hard water, containing a total hardness as calcium carbonate of 14.0 grains per gallon, while the North Side water shows only 6.3 grains. The pH value of both waters is 7.7. No determination of free CO_2 or oxygen has been made. Both supplies are raw, untreated, underground waters carrying a chlorine residual of about 0.1 p.p.m. The results of these tests conform to the general theory that, other qualities being similar, the action of water on a pipe varies inversely as the hardness. In the table added to the chart of flow tests, the mains shown as Numbers 1, 2 and 3 are located within a few blocks of the North Side plant; Numbers 5 and 6 are very close to the South Side plant, and Number 4 is about half way between the two plants.

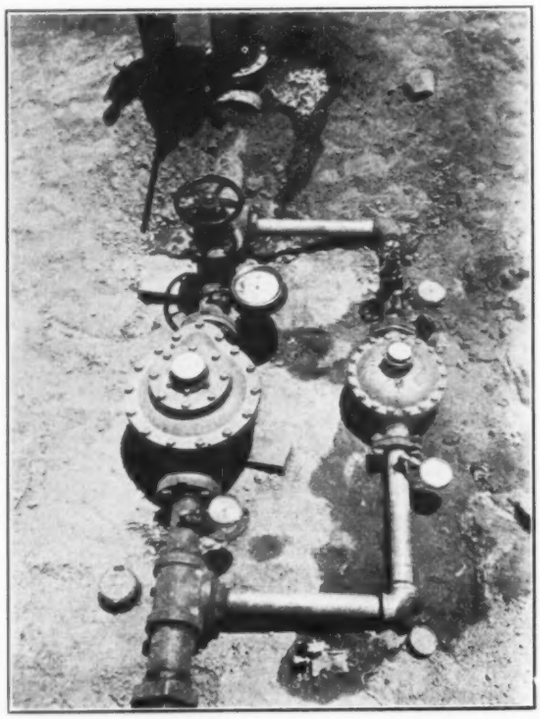


Plate 2—Apparatus and Set-Up for Calibrating Fire Hydrant Discharge.

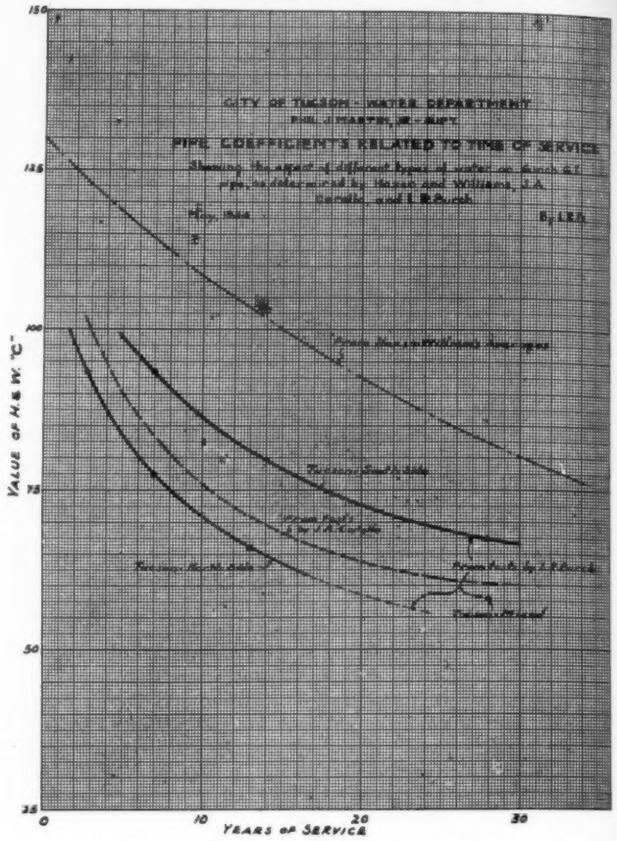


Fig. 2—Coefficients of Friction as Related to Years of Pipe Service at Tucson, Ariz.

The value of "C" calculated from these tests have been plotted against years of service, together with Mr Carollo's results and the average values shown in Williams and Hazen "Hydraulic Tables" for the same size of pipe. Apparently, the Tucson South Side water causes roughening of the pipe at a slower rate than the water carried in the mains which were tested by Mr. Carollo, while our North Side water causes somewhat more rapid loss of capacity. The three sets of experiments all show a much faster rate of inside deterioration than the average values assigned by Hazen and Williams, which are principally based on data covering soft and clear but unfiltered river water. After 10 years of service, the mains near the North Side plant in the city of Tucson have a carrying capacity *almost* 35 *per cent less than the Hazen-Williams averages.*

Mr. Carollo has kindly furnished me with a chemical analysis of the water with which he was concerned, but as he suggested, the ordinary chemical analysis alone is of no particular value in determining the action of water on cast iron pipe. His analysis shows a much higher mineral content than either of our supplies; the total hardness amounting to 28.4 grains per gallon. In order

to make a complete comparison, it would be necessary to study many other factors, including dissolved oxygen, free carbon dioxide, iron and manganese content, pH value, stray electric currents, organic and suspended matter, and completed bacterial determinations.

Our results are still very incomplete, but we consider the work quite valuable since several important facts have already been discovered, and many questions have been raised which will be studied in the future.

Our most important conclusions at the present time are:

(1) There is a much more serious resistance to flow in the pipe lines of the distribution system than was formerly suspected. *The deterioration is more rapid than is shown by most published data used in predicting future carrying capacities.*

(2) Quite a large part of the power used for pumping into the mains is wasted on overcoming friction loss in the pipes. When the South Side booster plant is pumping at full capacity, the feeder mains to the distribution system require about 19 more horsepower per 1,000 ft. of length than would be required to deliver the same pressure through smooth pipes.

(3) Cast iron pipe is affected much more rapidly than concrete pipe or concrete lined pipe. Two years ago a test of a 30-in. gravity line of concrete, which had been carrying South Side water for nineteen years, showed a Hazen-Williams "C" of 120.

These conclusions suggest a further study of the following problems:

(1) The possibility of using some different type of pipe material which will not lose capacity so rapidly. The comparative advantages of such materials as cement lined, bituminous lined, and asbestos-cement pipe will be considered before any large extensions are made.

(2) The economy of cleaning the present cast iron mains to restore the original capacity: this treatment might be applied periodically to certain large trunk mains.

(3) The advantages and disadvantages of chemically treating the water to reduce the action on the pipe.

Acknowledgment.—The above paper was presented before the Water and Sewage Section of the Arizona Public Health Association.

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Canadian Institute on Sewage and Sanitation Holds First Convention

The first annual convention of the newly formed Canadian Institute on Sewage and Sanitation was held in Toronto on October 18th and 19th—the total registration being 115.

The following officers were elected for the ensuing year:

President: W. M. Veitch, City Engineer, London, Ont.

Vice-President: G. H. Ferguson, Chief Engr., National Dept. Health, Ottawa, Ont.

Secretary-Treasurer: A. E. Berry, Chief Engr., Ontario Dept. Health, Toronto, Ont.

Trustees: N. J. Howard, Director of Water Purification, Toronto, Ont.; G. R. Jack, Comm. of Works, East York, Ont.

The technical sessions were opened with a paper presented by Wm. Storrie, Consulting Engineer, Toronto, Ont., dealing with "The Design and Construction of the Sewage Disposal Plant at Kitchener, Ont.," which consists of preliminary settling tanks and sludge digestion with glass covered drying beds.

Ray Knight of Toronto discussed "The Design of Refuse Incinerators," in which he brought out pertinent information necessary to the successful construction and operation of municipal incinerators. Mr. Knight's paper was followed by a short description of the "Refuse Disposal Methods Utilized in Toronto," by H. D. Bradley of the Toronto Department of Sanitation.

Geo. Phelps, Dept. of Works, Toronto, delivered a paper on "The Design of a Sewer System" which dealt with practices that had been found satisfactory for the City of Toronto and other large municipalities.

A round table discussion was held—the subject of sludge disposal being the foremost. The meeting closed with an inspection trip to three plants in the city. At the East York plant the novel "CALOCO" vacuum sludge filter was seen for the first time. To this filter the sludge is delivered directly to a horizontal filtering belt operating very much as a paper making machine does in dewatering the paper pulp to form paper. The extensions to the North Toronto activated sludge plant were next inspected and following this the Symes Road refuse destructor of the City of Toronto was visited.

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E. D. Burchard Elected President, M. F. Trice Secretary N. C. Associations

North Carolina Section of the A. W. W. A. and the N. C. Sewage Works Association held the joint annual meeting at Elizabeth City, N. C., Nov. 12th-14th with an attendance of 200 or more—the official registration being 157. Elizabeth City proved to be the host extraordinary and was so proclaimed by her guests to Jim Parker, Supt., and Manager of the local Utilities Commission and Bob Luther, Supt. of Filtration and Pumping.

President H. L. Shaner of Winston Salem, N. C., and M. F. Trice, serving as Acting Secretary,* had arranged an excellent program dealing with ground water supply and its problems, in which water softening practices were reviewed by C. P. Hoover, an authority of Columbus, Ohio, and thereafter North Carolina experiences were presented. Stream gaging, soil erosion problems and pumping were also discussed. A new scheme of chemical treatment of sewage at Winston Salem, N. C., was announced; and, safe practices in chemical handling and its application were presented by L. L. Hedgepeth.

Officers elected for the year were:

President—E. D. Burchard, U. S. Geol. Survey, Asheville, N. C.

Vice-President—E. S. Moss, Supt. of Plants, High Point, N. C.

Secretary-Treasurer—M. F. Trice,* State Dept. of Health, Raleigh, N. C.

Editor—W. E. Vest, Supt. Water and Sewerage, Charlotte, N. C.

*To fill the vacancy created by the resignation of the Association's "wheel-horse" for many years, Prof. H. G. Baity of Chapel Hill, N. C., also serving as State Engineer of P. W. A.

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Association Meetings Scheduled

*Dec. 28—**New York Section, A. W. W. A.** Hotel New Yorker, New York City. Secretary, R. K. Blanchard, Neptune Meter Company, 50 W. 50th St., New York City.

Jan. 3-5, 1935—**Texas Water Works Short School and Texas Section Southwest Water Works Meeting.** Hotel Driskill, Austin, Tex.

Jan. 10-11—**American Engineering Council.** Washington, D. C. Executive-Secretary, F. M. Feiker, 744 Jackson Place, Washington, D. C.

Jan. 15—**New York State Sewage Works Association.** Hotel McAlpin, New York City. Secretary, A. S. Bedell, State Department of Health, Albany, N. Y.

Jan. 16-18—**American Society Civil Engineers.** New York City. Secretary, Geo. T. Seabury, 33 W. 39th St., New York City.

OHIO CONFERENCE ON SEWAGE TREATMENT

THE Eighth Annual Ohio Conference on Sewage Treatment was held at Columbus, Ohio, on October 4th and 5th. The registration was 126 and the total attendance probably exceeded 150.

Officers chosen for the year 1934-35 were:

Chairman—W. B. Lockhart, Supt. Chem., Sewage Treatment Works, Fostoria, Ohio.

Vice-Chairman—G. Albro Hall, Supt. Chem., Sewage Treatment Works, Norwalk Ohio.

Sec.-Treas.—Albert H. Fretter, Supt., Sewage Treatment Works, Medina, Ohio.

Member of Exec. Com.—R. E. Burnett, Supt., Sewage Treatment Works, Marion, Ohio.

"Gadget" Competition

A novel feature of the meeting was the "Gadget Competition" which was open to all operators of sewage treatment plants in Ohio. Twenty-one devices or working models of devices, developed by operators for use in sewage plant operation or in laboratory control, were entered and displayed. Three prizes were awarded as the result of a popular vote of the registered attendance.

A color comparator entered by M. W. Tatlock, Supt., Sewage Treatment Works of Dayton, won the high prize of $10.00. A sewage sample carrier, entered by G. E. Flowers, Supt., Southerly Sewage Treatment Works of Cleveland, was second and received the award of $5.00. A gas collection trap, entered by Orville Lantz, Operator, Sewage Treatment Works of Dayton, was awarded third prize—a subscription to "Sewage Works Journal."

Ingenious and useful devices for operation and plant control thus brought to the attention of the operating engineer and the designing engineer constituted a novel and purposeful display, not before staged at such meetings. In this, there lies a suggestion for other associations.

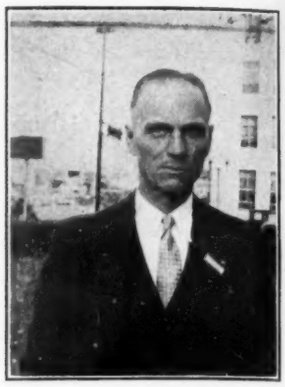
"Recent Trends in Sewage Treatment"

The dinner address by Louis R. Howson, Consulting Engineer of Chicago, constituted a picturized review of recent trends in sewage treatment.

Mr. Howson stated, that on practical rather than theoretical grounds, by-passes around the several units comprising sewage treatment plants were essential for flexible and successful operation. Mechanical bar screens controlled automatically by loss-of-head in the sewage flow had prove satisfactory and economical. Screenings, which in the past had been difficult of disposal, were being ground and returned to the sewage or else incinerated. Satisfactory equipment had been developed for grease removal, which material assists in the burning of screenings. The old grit channel, over which the designing engineer had labored in efforts to provide satisfactory capacities and velocities for variable sewage flows, had been largely replaced by equipment for the positive removal and washing of grit—such as the Dorr Detritor. In the sedimentation of sewage, much thought was being given to tank designs and to the correction of short-circuiting. Lately the cross-flow tank was being supplanted by the more efficient radial flow types. Straight line flow with drag-line equipment was also being used and the Milwaukee development known as the "suction sludge" removal equipment was also cited.

Turning to the ever important sludge, Mr. Howson pointed out that 80 to 100 deg. F. for digestion tanks was now considered optimum. Thermophylic temperatures had offered no practical advantages, but rather had led to "gumming" of the sludge and an increased volume of rank supernatant. Although as much as 14 cu. ft. of gas per pound of volatile solids might be obtained, the usual range seemed to be 7 cu. ft. to 12 cu. ft. Since 0.25 to 0.33 cu. ft. of gas per pound of volatile solids had been sufficient for heating sludge, attention had been given (with success) to the development of power from sewage gas, in which 80 per cent of sludge heating could be accomplished by gas engine exhaust and engine cooling water. A gas purifying box containing "iron sponge" (iron oxide and wood shavings) had been developed to "scrub" out sulphur compounds and purify the gas. In the operation of sludge digestion tanks there was now a tendency toward handling the sludge on a "cash-register" basis; and, accurate control with digester invoices to determine the unknown elements, now being carried on at many sewage treatment plants, represented a definite step forward. In this connection the "tipping bucket and sludge meter" developed by W. A. Speary, at the Aurora, Ill., plant, was a recent invention.

G. A. Hall, Norwalk, O.



A. H. Fretter, Medina, O.

In trickling filter design, attention had been given to the adoption of suitable false bottoms for the filter and to better distribution of the sewage on the filter through the medium of traveling or rotating distributors. The tendency in design now was to swing away from deep fillers and provide more surface and shallower units. Recent court decisions had not changed the trend toward the use of the activated sludge process and its applicability was being extended.

Chlorination was with certainty being recognized more and more as a useful adjunct to sewage treatment and disposal processes. Its application and uses had been set forth in detail in the recent report—"Sewage Chlorination"—distributed by the American Public Health Association. As to chemical precipitation processes, designing engineers had adopted the position of waiting for further data on performance and costs.

Greater attention to proper operation of sewage treatment plants, to good housekeeping and to landscaping, indicated that the appearance and performance of the municipal sewage treatment works was becoming a matter of civic pride.

Technical Sessions

(Chairman, J. R. Collier, presiding)

"Balancing of Sewage Solids"—FRANK WOODBURY JONES, Sanitary Chemist, with GEORGE B. GASCOIGNE, Consulting Engineer, Cleveland, Ohio.

Mr. Jones pointed out that accuracy of the data obtained in measuring solids handled by a sewage plant is

*It is regrettable that this report, prepared for our November issue, had to be held over for this issue.—Editor.

Jim Collier, Elyria, O.

F. Woodbury Jones, Geo. B. Gascoigne, Engineers, Cleveland, O.

dependent on (1) sampling methods and (2) analyses. For instance, suspended solids might be determined either by the "difference method" or by the "Gooch crucible method." Depending on the character of the sewage, one or both of these methods were applicable. Results of suspended solids determination for a month, taken from data accumulated at the Elyria sewage treatment plant where both methods have been used concurrently, indicate that they will check sufficiently well and will tell the truth. From suspended solids determinations of the trickling filter effluent and of the final tank effluent at Marion, O., a calculation of the dry solids removed resulted in 337,000 pounds. Plant records show that 345,000 pounds of dry solids were removed from this tank, indicating that laboratory and plant records may be reasonably close.

In balancing sewage solids that are put into sludge digestion tanks, there are these phases of accounting:

(1) Determine solids removed in sedimentation tanks by analyses. (2) Check the calculated solids removed with those actually delivered to the digestion tank in the form of sludge. (3) Measure digested sludge removed from digesters and determine solids (total and volatile). (4) Measure supernatant liquor and determine solids therein. (5) Measure gas produced and determine its relation to volatile matter destroyed.

A comparison of these results will disclose the losses of solids and indicate where these losses occur. Balancing of sewage solids, said Mr. Jones, becomes the task of procuring, selecting and expressing data to present a true picture of what takes place within the sewage treatment plant.

C. B. HOOVER, Supt., Div. of Water and Sewage Disposal, Columbus, remarked that he was thoroughly in accord with making attempts to account for sewage solids and to keep accurate records of sewage plant operation insofar as it was practical. Changes within a sewage plant were so intricate, however, that balancing of solids required marked scientific exactness.

G. ALBRO HALL, Supt., Sewage Treatment Plant, Norwalk, Ohio, said that he is handicapped at his plant by lack of personnel but that an effort to collect and record data for the balancing of sewage solids had disclosed, so far, an error of about 15 per cent.

"Sealing Abandoned Coal Mines"—B. F. HATCH, Assistant Engineer, Ohio Department of Health, Columbus, O.

Mr. Hatch outlined the mine sealing work in Ohio conducted as federal public work projects (C.W.A. and F.E.R.A.) and supplemented the paper with lantern slides picturing sealed openings and coal mine conditions in the southeastern part of Ohio. He explained that the real problem of correcting coal mine drainage resolved itself into sealing off openings to exclude air (oxygen) from the mines, thus eliminating or at least minimizing the oxidation of pyrites (iron sulphides) which is the source of sulphuric acid and ferrous iron in the drainage waters. The practice was to close all dry drift openings with earth fill or a masonry barrier where necessary. In closing drift openings from which drainage is flowing, two general types of stoppings are used: (1) A low masonry dam across the opening, behind which is constructed a masonry curtain wall extending from the mine roof to a point below the crest of the dam; (2) A solid masonry wall through which, at a point near the floor, a sewer pipe trap or a trapped masonry opening is constructed to relieve pressure but maintain a seal.

(For further details, see Mr. Hatch's article in the March, 1934, issue of WATER WORKS AND SEWERAGE.—Ed.)

As of October 1, 1934, Mr. Hatch reported 2,089 mine openings had been closed and at the present time 400 to 500 openings are being closed per month. Analyses of samples of drainage from mines which had been more or less completely sealed showed a marked reduction in acidity and some flow reduction in several instances.

R. D. SCOTT, Chief Chemist, Division of Laboratories, Ohio Department of Health, said that samples of mine drainage which had so far been analyzed, had a wide variation in composition. Some were essentially dilute solutions of ferrous sulphate, whereas others contained large portions of ferric sulphate with more or less aluminum sulphate. A water containing 1,500 p.p.m. ferrous iron had a deoxygenating value of 215 p.p.m.—each 7.0 p.p.m. of ferrous iron requiring 1.0 p.p.m. In receiving streams fish were killed either by oxygen depletion, by low pH or by concentration of iron salts. In general, less than 3.3 p.p.m. oxygen, or pH below 5.0, or 10 p.p.m. or more of dissolved iron would result in fish mortality.

"Separate Sludge Digestion Tanks and Their Operation"—W. B. WALRAVEN, Chief Engineer, Springfield, Ill.

Mr. Walraven discussed the essential features of separate sludge digestion tanks and their operation, in the light of his experiences at the Springfield plant. The latter is of the activated sludge type and serves a population of about 70,000 contributing a flow of 7.0 m.g.d. of essentially domestic sewage. Excess activated sludge being returned to the incoming sewage, a mixture of primary and activated sludge reaches the digestion tanks. The six digestion tanks provided, (each 41.0 ft. in diameter by 41.0 ft. deep) furnishes a capacity of about 28,000 cu. ft., four being used as primary digestors and two as digested sludge storage tanks. Three tanks have Downes floating covers, the fourth a gravity type gas holder. The secondary or storage tanks had not been covered.

Mr. Walraven said that there seemed to be no unanimity of opinion with reference to required capacity of separate sludge digestion tanks as evidenced by a comparison of design figures at five recently designed plants in Illinois, all of which receive sewage classed generally as "domestic." Capacities of these ranged anywhere from 2.24 cu. ft. per capita to 4.88 cu. ft. per capita. At Springfield the capacity was 2.40 cu. ft. per capita. Operation problems would be reduced if this be increased, but the operation with well heated tanks receiving mixed primary and activated sludge had been very satisfactory on the whole. Satisfactory results could in all probability be obtained with even a lesser capacity if more attention were given to digestion

control. An effort was being made to maintain digestion tank temperatures between 95 and 100 deg. F. against the former practice of 80 to 85 deg. F. The practicability of thermophylic temperatures (115 to 135 deg. F.) was questionable, although interesting experiments were being made in this direction. At Springfield the sludge pumping operation was such that the proportion of fresh solids added to digesting sludge is about 1 to 6 by volume.

Mr. Walraven called attention to the bearing that the position of heating coils in digestion tanks had on the heat required and heat transfer. Coils, he thought, should be placed in the zone of most active digestion and far enough from tank walls to permit free heat convection currents around the pipes. The coils in the Springfield digestion tanks formed a hexagon and were so placed that the angles were almost 2 ft. from the walls. A good design was to place the lower coil at a distance of 3 or 4 ft. from the bottom of the tank and the upper coil somewhat above mid-depth. The temperature of circulating water at Springfield had been lowered from 170 F. to 155 F. to avoid sludge caking on the pipes and thus to permit of better heat transfer. More uniform heating of the tank had resulted. On one test, when solids in the supernatant liquor were 0.36 per cent and solids below the supernatant liquor were ranging uniformly with depth from 5.03 to 12.0 per cent, the temperatures at 3 ft. intervals of tank depth did not vary by more than one degree from 92 deg. F.

He considered that heat losses from digestion tanks should be given more thought. A test on the digestors at Springfield last winter indicated that about 56.5 per cent of the heat produced was being usefully employed. Since the heat was being salvaged from gas engine exhaust, that loss was of little concern at Springfield, but, in general, more thought should be given to better tank insulation in the future and especially so in the colder climates.

Foaming of digestion tanks and the heavy accumulation of scum on the tanks had been experienced in the Springfield operation as elsewhere. The foaming scum was being discharged to the digested sludge storage tanks where it loses its identity. It had been found that if scum on digestors is let alone it would gradually digest and disappear and experience had indicated that simple and common sense practice in digester operation was the most satisfactory.

Supernatant liquor was ordinarily returned to the incoming sewage. When the character of the liquor had been bad, efficiency of the sedimentation units was sacrificed, but the over-all effect on the stream had been better with this procedure than when the liquor had been by-passed to it. Lagooning of supernatant liquor constituted a ready and efficient means of disposal and had been practiced to some extent at Springfield. By this token, it was undoubtedly true that stage digestion results in a much better supernatant liquor.

For sludge mixing in the digestion tanks at the Springfield plant, Mr. Walraven said that dependence is placed on the velocity of incoming sludge, gas ebullition and convection currents, with a minimum of artificial disturbance—not exceeding 15,000 g.p.d. sludge input. Analyses of digested sludge (1933) gave an average total solids content of 8.40 per cent and a fixed solids content of 56.8 per cent.

Sludge gas was being utilized in the development of power for plant operation at a substantial saving in operating costs. A gas engine together with heat salvage equipment, one new Downes floating cover and a 23,000 cu. ft. gas holder, installed at a cost of $15,728.00, had been placed in service the first of January, 1933. A Clark engine (180 hp.) is directly connected to a Connersville air blower requiring 525 k.w.h. to compress 1.0 million cu. ft. of air.* The saving in electrical power in twenty-one months of operation had averaged 60,000 k.w.h. per month and during the nine months of 1934, 80,500 k.w.h. per month. To date the gas engine had paid for itself two and one-half times. In fact, it had been so satisfactory that a second 150 hp. unit had been purchased for installation. The gas production at the plant nominally will not be sufficient to operate both units twenty-four hours a day continuously but the gas now wasted justified the additional engine purchase.

Mr. Walraven said that although separate sludge digestion as an efficient and economical method of disposal is being challenged by mechanical filtration of undigested raw sludges, gas utilization for power will tend to support digestion practice at many plants. After deducting the anticipated operating savings for 1934, resulting from gas power produced, from the annual capitalization, maintenance and operation charges of the digestion equipment at Springfield, there is left a net annual cost of only $2,775.00 to pay for sludge handling and ultimate disposal.

Floyd G. Browne, Supervisor of Sewage Plant Operation at Marion, Ohio, described the operation of the separate sludge digestion Dorco tank at Delphos, Ohio, which had been placed in service by completely filling it with raw sewage, by continuously operating the stirring mechanism and by gradually heating it to a temperature ranging between 70 and 80 deg. F. No difficulties with foaming had been experienced and no pH corrections were needed. A digestion tank temperature ranging between 80 and 90 deg. F. had produced better results and probably had effected an increase in gas production. Supernatant liquor returned continuously to the settling tank influent had presented no serious problem and Mr. Browne stated that difficulties with supernatant liquor could be greatly minimized by obtaining maximum concentration of raw sludge to limit the volume of input and maintain a low rate of pumping to the digestion tank and thus minimize disturbance of the contents of the digester.

G. Albro Hall, Supt., Sewage Treatment Plant, Norwalk, Ohio, stated that at the Norwalk plant it was usual practice to concentrate the raw sludge in the clarifiers by carrying a blanket of some depth, but the presence of milk wastes in the sewage occasionally disrupted this procedure, making necessary the pumping of very thin sludge to the digestion tank. However, the crude sludge had averaged 7.0 per cent total solids, of which 57 per cent has been volatile matter. The digested sludge removed had averaged 11.5 per cent solids, of which 34 per cent had been volatile. The solids reduction had averaged 35 per cent and the volatile matter destroyed 61 per cent.

J. R. Collier, Supt., Sewage Treatment Works, Elyria, Ohio, referred to the operation of the separate sludge digestion units at the Elyria (activated sludge) plant, equipped with primary Imhoff tanks (sludge capacity of 1.1 cu. ft. per capita) and two separate sludge digestion tanks equipped with Downes floating covers which furnish an additional sludge digestion capacity of 2.64 cu. ft. per capita. Mr. Collier stated that, although it was originally intended to use the sludge compartments of the Imhoff tanks for partial sludge digestion, experiences had proven that a very thin sludge was obtained during the first (acid) stages of digestion and this had led to serious taxing of the separate sludge digestion tanks. The present, and more satisfactory,

*This pioneering installation is described in Water Works and Sewerage for May, 1933, in an article by Mr. Walraven.—*Ed.*)

Floyd Browne, Marion, O.

C. C. Hommon, Superintendent Sewage Treatment Works, Canton, O.

practice was to utilize the Imhoff tanks strictly for sedimentation and concentration of raw sludge, the latter being as completely removed as possible to the digestion tanks at intervals of two or three days. The two digestion tanks were now being operated as 1st and 2nd stage digesters, heat being applied to the primary tank only.

Round Table Topics

(1) **"Chlorination of Sewage"**—J. W. ELLMS, Chief Engineer, Water Purification and Sewage Disposal, Cleveland, O.—Leader.

Mr. Ellms briefly reviewed the history of sewage chlorination and set forth the two principal objects of its use, namely, the oxidation of objectionable organic compounds, odor control, and the destructin of pathogenic bacteria. He called attention to the lowered cost of chlorination in recent years which made its use more practical.

Chlorine reacts quickly with a large number of compounds which are contained in sewage. Therefore, the amount of chlorine required to produce a desired effect was dependent on the condition and concentration of oxidizable organic and inorganic matter in sewages and the period of contact. Chlorine applications to sewage would vary from 5 to 20 p.p.m., stale sewages having the highest demands. For optimum results some engineers have advocated a chlorine residual of 0.2 to 0.3 p.p.m. after a contact period of 15 to 20 minutes.

Few sewage works are properly designed for the efficient application of chlorine and more attention to this phase of design seems warranted. There was, in his opinion, need for machines of much larger capacity which would feed liquified chlorine direct to sewages. Refined accuracy was not paramount in sewage chlorinator design and these would be preferable to the use of evaporators which are required at present to convert the liquid to gas when the rate of feed is fairly high as at large works. Costs of sewage chlorination would vary widely with the amounts used. Per million gallons, the cost would range from $1.50 to $6.00.

[Later Mr. Tatlock cited a cost of $1.40 per m.g. for application of 12.5 p.p.m. chlorine at the Dayton plant where the lime-chlorine process is used.—*Ed.*]

A. E. HESS, Supt., Sewage Treatment Works, Alliance, Ohio, said that chlorination was being practiced at Alliance primarily for odor control. It was being applied at two points, to the crude sewage ahead of the screen chamber and to the Imhoff tank effluent to minimize odor produced by sprays on the trickling filters. He added that conditions in the collection sewers and trunk sewer were such as to permit a septic sewage condition and probably pre-chlorination at a point up-sewer from the plant would be the better procedure.

C. C. HOMMON, Supt., Sewage Treatment, Canton, O., related an experience at Canton wherein a section of 39-inch segment block trunk sewer had failed, due to disintegration caused by hydrogen sulphide liberated from the septic sewage. The sewage treatment plant was approximately seven miles below the city and the sewage in this long trunk sewer, in which is included one long and two short depressed sections, becomes very septic. Experiments to justify chlorination at a point up-sewer from the plant to delay sewage decomposition was made several years ago but the municipal officials could not at that time be convinced of its need. It is anticipated that with the reconstruction of the sewer section this will be done. Mr. Hommon added that chlorine had been successfully applied just ahead of the Canton sewage treatment plant to control odors.

FLOYD G. BROWNE, Consulting Engineer, Marion, Ohio, described the use of chlorine as it has been applied to sewage treatment at a number of the plants under his supervision. At Delaware, Ohio, chlorination equipment had been installed during this year to apply chlorine ahead of the wet well for the primary purpose of controlling odors. Reasonable success had been had in controlling odors with a chlorine application of 18 to 20 p.p.m. to a very concentrated domestic sewage, having a 5-day B.O.D. of about 350 p.p.m. Other beneficial effects have been an improved performance of the Imhoff tanks, a reduction of tank skimmings by about one-third and the elimination of hydrogen sulphide corrosion of plant equipment.

At Delphos, Ohio, chlorine has been applied successfully to the settling tank influent at a rate of 5 to 6 p.p.m. for the primary purpose of increasing tank efficiency and of delaying bacterial action in the settled sewage until sufficient dilution is afforded down stream for disposal without nuisance.

At Bellefontaine, Ohio, which is served by an old plant of the single story settling contact bed type, chlorine had been applied to the plant effluent to delay bacterial action in a small stream in which the ratio of dilution water to sewage plant effluent is about 1 to 15 during dry weather.

At Celina, Ohio, where a settled municipal sewage together with milk waste and tomato canning waste is discharged to a stream of practically no flow, chlorine is applied to the municipal sewage plant effluent at the rate of about 20 p.p.m. and, although not a solution for the correction of the seriously polluted stream, had reduced odors and slime conditions in the stream.

M. W. TATLOCK, Supt., Sewage Treatment, Dayton, Ohio, reviewed experiences at Dayton with the lime-chlorine pre-treatment process. He stated that the average ratio of chlorine to lime in the mix applied is 1 pound chlorine to 1.1 pounds of hydrated lime and that the rate of application of chlorine on the average daily sewage flow is 12.5 p.p.m. Although this treatment was introduced primarily for odor control, plant efficiency had been increased as measured by an additional B.O.D. reduction of about 15 per cent. The cost of the treatment over a period of one year had been $1.40 per million gallons. He added that in his opinion, the use of lime is justified because of the increased effectiveness of chlorine and because of reduced maintenance costs as the result of less corrosive action on equipment.

A. H. NILES, Supt., Sewage Treatment, Toledo, Ohio, stated that at Toledo post-chlorination is practiced almost entirely for the purpose of disinfection of the sewage prior to its discharge into Maumee River (virtually Maumee Bay) which is used for recreational purposes. He referred to the septic condition of the sewage as it reaches the plant and that pre-chlorination as well as post-chlorination seemed ultimately advisable.

B. H. BARTON, Chief Operator, Sewage Treatment Works, Findlay, O., said that the use of chlorine at the Findlay plant delayed bacterial action and thus had a beneficial effect upon the river. The rate of chlorine application has been 11.1 p.p.m.

G. ALBRO HALL, Supt., Sewage Treatment, Norwalk, O., stated that post-chlorination at the Norwalk trickling filter plant, used primarily to inhibit biological growths in a dry stream, costs $1.50 to $1.75 per m.g. The rate of application averages 2.0 p.p.m. to the filter effluent.

(2) **"Laboratory and Laboratory Control as Applied to Sewage Plant Operation"**—C. D. MCGUIRE, Chemist in Charge, Sewage Treatment Works, Columbus, O.-Leader.

Mr. McGuire called attention to the objects of laboratory tests and analyses. The operator in charge of a sewage treatment plant was first of all concerned with the efficient operation and performance of the equipment which he had; secondly, with research and experimental work which might assist in the design of new works or be of benefit to the art of sewage treatment in general.

Control tests were of four kinds: Those showing the effect of sewage treatment processes on the sewage solids; those showing the effect on oxygen requirement; those showing the effect on the receiving stream; and, those showing the comparability of samples collected at the various stages throughout the plant. He stated that laboratory control presented many problems and suggested free discussion of laboratory problems, to arrive at a better agreement and understanding among chemists.

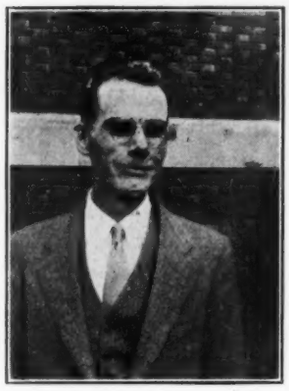
W. A. YACKLEY, Chief Chemist, Sewage Treatment Works, Dayton, O., discussed the errors and difficulties arising in making dilutions for B.O.D. determinations. He believed that much more consistent results could be obtained by making dilutions on relatively large volumes of the samples and withdrawing the usual (approximate) 250 cc. portion of the dilution for incubation. He stated that he had found it desirable in D.O. determinations to titrate 100 cc. portions of the samples with N/40 thiosulphate instead of the whole contents of the 250 cc. bottles, so that checks could be made in case of error. He also preferred the use of aluminum dishes to porcelain in the determination of solids.

F. W. JONES, said that laboratory routine could be lessened, without materially sacrificing the accuracy of results, by making solids determinations on weekly composites preserved with formaldehyde.

C. D. MCGUIRE remarked that although the chlorine demand test had been given relatively little consideration by operators in general, it was his opinion that it would supply valuable information when considered with other analytical data. The demand for chlorine was indicative of the degree of purification or mortification or the sewage.

C. D. McGuire, Superintendent Sewage Treatment Works, Columbus, O.

M. W. Tatlock, Superinment, Dayton, O. His Problem Is Odor Control; His Hobby, Selling Sludge to Pay for Odor Control.



B. H. Barton, Findlay, O.

T. C. Schaetzle, Akron, O.

(3) **"Is it Feasible and Economical to Market Sludge?"**—M. W. TATLOCK,* Leader.

Mr. Tatlock introduced his topic by reviewing the experiences in the preparation and marketing of sewage sludge at Dayton.

The cost for dryer and grinding equipment at Dayton for the first three years was only $3,962.00. This year improvements including a sludge storing building, have been undertaken. Over the period from January 1st, 1932, to October 1st, 1934, 3,535 tons of sludge, or approximately two-thirds of the total production, had been marketed. The total cost of operation and maintenance had been $4.75 per ton of sludge produced in bags for the trade. Small quantities were sold at $1.00 per hundred pounds; quantities from 1 ton to 25 tons, at $11.00 per ton. Sales made are strictly for cash at the plant. The revenue had been such that a small profit is realized.

The product is marked and sold as "Sewage Sludge." Under the Ohio law, commercial fertilizer must meet the so-called "16 unit" requirement, hence no effort has been made to build up the sludge. A permit is obtained from the Ohio Department of Agriculture to market sewage sludge of a guaranteed analysis, as follows: 2.28 per cent Nitrogen; 1.40 per cent Phosphoric acid; 0.12 per cent Potash. By actual analysis, the constituents exceed the guarantee.

Recently a Royer Sludge Disintegrator had been purchased for preliminary shredding of the sludge ahead of the dryer, thus assisting in the drying operation. The moisture content of the sludge had to be lowered to about 10 per cent to avoid heating of the stored product. Some odors result from drying but these are reduced by washing the stack gases with water spray.

T. C. SCHAETZLE stated that in giving consideration to the drying and marketing of sludge at Akron he had made a rather intensive survey of what had been done through the country in this respect. He found that Ohio was more "sludge sale minded" than other states.

*In his article "Sewage Sludge—Its Preparation and Sale," Mr. Tatlock will fully discuss the Dayton experiences with sludge marketing in the next issue of WATER WORKS AND SEWERAGE.—Editor.

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STATE WATER AUTHORITY URGED FOR NEW JERSEY.—Creation of a water authority, patterned after the Allegheny County Authority in Pennsylvania and New York Port Authority, and centralization of responsibility for the water supply of the state are urged in the annual report of the State Water Supply Commission of New Jersey.

OHIO CONFERENCE ON WATER PURIFICATION

THE Fourteenth Annual Ohio Conference on Water Purification was held in Columbus on October 2nd and 3rd.* The attendance this year was the largest recorded—126 having registered with about 150 total in attendance:

Officers elected for the year 1934-1935 were as follows:

Chairman—M. M. Braidech, Cleveland, O.
Vice-Chairman—Frank S. Taylor, Defiance, O.
Secretary-Treasurer—W. B. Lockhart, Fostoria, O.

Technical Sessions

(Chairman J. M. Montgomery, presiding)

The meeting was opened with a review of the outstanding papers on water purification that have appeared during the current year, by Clarence Bahlman, Water Purification Supervisor, Cincinnati.

An especially interesting paper dealing with the subject "Industrial Waters" was presented by C. P. Hoover, Consulting Chemical Engineer of Columbus. Mr. Hoover covered only a few of the industries requiring especially treated water, including water for steam making purposes; for ice making; for brewing and baking. He emphasized the fact that the character of the raw water must determine the method of treatment best suited to give the proper results, the final selection of process to be made from the several available methods. For example: Water for ice making should be treated to leave as little total solids as possible. On the other hand, water having a high sulphate content seemed to be the most favored for the brewing and the baking industries where yeast cultures are involved.

W. C. LAWRENCE, Supt., Baldwin Filtration Plant, Cleveland, pointed out that most of our efforts in the past have been toward making a palatable water and too often no attention has been paid to industrial use of water when establishing a water works and a treatment plant. He believed that we should now turn our attention to producing a better water for industrial use. Certainly, more of our municipal supplies should be softened, at least to some degree, he said.

E. NORDEL, Engineer, Permutit Company, New York City, said that some industries found it profitable to remove the hardness from water which had an original hardness content of as little as 10 p.p.m. Some industries, notably the brewing and baking industries, require two supplies; one for process use and the other for steam making. Refinements in industrial supply were increasing.

M. M. BRAIDECH, Senior Chemist, Baldwin Filtration Plant, Cleveland, reported that a national chain of bakeries, faced with the use of as many various kinds of water as the number of cities in which they operate plants, had found it expedient to prepare synthetic water for bread making so as to get uniformity of results at each plant.

F. J. MCINTYRE, Consulting Chemist, Columbus, described a water which is being used by a large department store in the city for temperature regulation. Water at 54 deg. F. obtained from a well 340 ft. deep, had a hydrogen sulphide content of 25 p.p.m. and was very corrosive to iron piping. To check corrosion damage, electrodes had been introduced in the system and a current of 40 volts and 20 amperes applied. Changes in the electrical charge in the water and on the system are said to have practically prevented corrosion. Since the Columbus Sewer Department did not wish the large quantity of spent water with such a high hydrogen sulphide content entering the sewer system, the company had drilled a second well 60 ft. distant from the first well and to a depth of 380 ft. After passing through the circulating system, the water was being discharged into the second well. Such a method of disposal of used water had increased the temperature of the supply only about 1 deg. and had done away entirely with the odor difficulty. Water was being recirculated at the rate of 2 m.g.d. and constituted a unique and effective solution of the once perplexing problem.

Engineers' Registration Law Discussed

W. W. GRAF, City Engineer of Lancaster and member of the State Board of Registration of Engineers and Surveyors, discussed the Ohio Act requiring the licensing of engineers in the various engineering fields. Under this law the operation of all public utilities including water works must be in charge of a licensed engineer. He reported that a new classification has been included by the board—that of Water Purification Engineer. He said that, under this law, it will be necessary to have all water purification plants in charge of licensed men after January 1st, 1935. He felt that the law should have a stabilizing effect in plant operation as there will not be the incentive to change personnel at water purification plants with every change in municipal politics. This, however, was an evil from which Ohio had suffered less than some of her neighboring states.

M. M. Braideck, Cleveland, O., Chairman Elect of the Conference.

Jas. M. Montgomery, Piqua, O., Retiring Chairman of the Conference.

*It is regrettable that this report, prepared for our November issue, had to be held over for this issue.—Editor.

Chas. P. Hoover, Chemical Engineer, Columbus, O.

Tommy R. Lathrop, Conference Editor.

JOHN H. HEPLER, Assistant Engineer, State Department of Health of Michigan, explained how the State licensing law for engineers and operators had worked in Michigan. It had been a great help, he said, in preventing the discharge of trained filter-plant operators during periods when changes in other municipal personnel had been violent.

Variations in Lactose Fermenting Organisms In an Impounded Water Supply

An aerobic spore-bearing, gas-forming bacterium which gives much the same reactions as the coli-aerogenes group was described by Clarence Bahlman of Cincinnati. The organism had suddenly appeared in the water supply of Blanchester, O., during the spring of 1933 and disappeared in the summer and again reappeared in the spring of 1934. It resisted excess lime treatment and also ammonia-chlorine residuals of from .25 to .50 p.p.m. Its reactions were typical of true b. coli in standard tests and the making of spore tests had been necessary to demonstrate that this organism did not belong to the coli-aerogenes group. Mr. Bahlman pointed out that the completed test when applied to the Cincinnati supply had also shown some cultures which proved to be aerobic spore formers. The anaerobic gas-former is quite common in many water supplies but the temporary appearance of *aerobic* spore-formers is unusual. Like the anaerobes, he said, these aerobes were highly resistant to chlorine and caustic lime treatments and would cause suspicion to be placed on the supply containing them.

A Study of Non-Colon Lactose Fermenters In Water Supplies

E. B. EVANS, Senior Chemist of the Cincinnati Water Purification Plant, made a study of five special medias as possible adjuncts in making confirmatory tests of the chlorinated water supply of Cincinnati, the purpose being to determine their value in avoiding false presumptive tests when following (A.P.M.A.) Standard Methods of Water Analysis. The appearance of non-confirming gas-formers is becoming increasingly prevalent. At least 80 per cent of the gas-formers confirmed as coli-aerogenes during the period from 1922 to 1926, whereas, only 29 per cent confirmed during the period from 1926 to 1931. And, during the years 1932, 1933 and 1934 this has fallen to but 15 per cent.

Tests were made in which five liquid media were used for fermentation. The standard confirmation was made on E.M.B. media with a secondary fermentation. In addition, the test for spores was made. The results follow: Of 64 inoculations in various media only 1 showed gas in Brilliant Green Bile broth; 4 showed gas in Stark & England broth; 30 showed gas in Dominick & Lauter broth; none showed gas in Ritter's or Salle's broth. The E.M.B. plates gave 21 sterile and 9 negative when using Dominick & Lauter broth. Of the 9 negatives, 5 inoculated into broth gave gas and 4 did not. Plates from Brilliant Green Bile broth gave positive gas production. Mr. Evans concluded, from results of the study, that the A.P.H.A. standard test for coli-aerogenes is best suited for conditions at the Cincinnati plant. Had one of the non-standard media been used during the past thirteen years, the conditions of change in the character of Ohio River conditions, which has gradually taken place, would never have been known.

The Hydraulics of a Rapid Sand Filter*

GALE DIXON*, Consulting Engineer of Youngstown, presented a paper which was a resume of investigations on the above subject during the past several years, together with data on a comparative study of the hydraulics of the washing system for rapid sand filter units of 4 m.g.d. capacity, with alternative designs of filter underdrain systems. The topics covered included discussions of the optimum rate of wash; the initial loss of head in filtration; loss of head in washing; examples of hydraulic losses in complete wash water systems.

Mr. Dixon referred to that very important contribution to the technique of filter washing, resulting from the investigations by Hulbert & Herring at Detroit. He concluded that initial losses in filtration were due to several factors, viz: the rate of flow; the depth of sand; the size of sand; and the temperature of the water—the relative importance of these various factors, according to recent investigations by Fair and Hatch, were cited.

Loss of head in washing comprised the sum of the losses in the wash water piping, the piping in the individual filter, the underdrain system, the gravel and sand, and the head over the lip of the gutter. Examples of hydraulic losses given for complete wash water systems compared the head losses in the Wheeler bottom filter and those of the perforated pipe underdrain system. In the Wheeler type the loss was about half that in the latter. In terms of practical operating performance the Wheeler bottom design made possible a higher rate of rise of wash water, other things being equal, and was less costly to provide.

*An article on "Hydraulics of the Rapid Sand Filter" by Mr. Dixon is scheduled for a near future issue of WATER WORKS AND SEWERAGE.—Editor.

John S. Gettrust, Superintendent Filtration, Youngstown, O.

Gale Dixon, Consulting Engineer, Youngstown, O.

Miscellaneous Plant Problems

Under "Miscellaneous Plant Problems" several subjects were discussed.

Cross Connections: The problem of cross connections between private and public water supplies was of considerable interest. The Conference voted in favor of following the lead of the American Water Works Association in regard to holding its future conventions in hotels only where there is a certified public water supply provided, and the supply system conforms to all cross connection regulations of the State Health Department.

Gas Asphyxiation: Of importance to those operating lime-soda softening plants, was the description by J. S. Gettrust of Akron of the near fatality to three men working in the CO_2 reaction tank at the water works at Hudson. This plant is a lime-soda plant employing recarbonation, the carbon dioxide being generated in a coke furnace. The reaction tank is of steel with a conical roof and a trap door in the roof. There is a down-comer in the center of the tank to carry the settled water to the filters. As water passes down in this down-comer CO_2 gas is introduced in the bottom and rises through the down flowing water. Men entered the top of the tank and were working on a platform above the water. Of the three men working, one came to the ground and discovered that he was almost helpless. On looking up, he saw one of the others hanging unconscious out of the trap door. He sent for assistance to get the two men down. The third was still in the tank and had not been seriously affected up to that time, but was affected some days afterwards.

Several men in charge of plants employing recarbonation told of similar, but less severe, experiences. Whether the gas causing the poisoning was carbon dioxide or carbon monoxide was of little importance to the mind of J. M. Montgomery. The fact remains, he said, that we are dealing with a toxic gas and these experiences emphasize the importance of caution and proper ventilation when working around carbonating equipment.

Amebic Dysentery

Leo F. Ey, Director of Laboratories of the Ohio State Department, read a paper on amebic dysentery, with special reference to the epidemic (721 cases) which originated in Chicago in 1933 in two hotels.

Dr. Ey said that it was not until 1927 that it was definitely proven that of the five intestinal ameba only one, Endameba Histolytica, is pathogenic. The disease came about by the ingestion of the encysted organisms because all active organisms were destroyed in the stomach.

Chlorination of a water supply was no protection against this organism because it had been found that in the encysted organisms was resistant to 25. parts per million of chlorine. Filtration, however, did remove it from water.

There was evidence, he said, that the Chicago epidemic was caused by a carrier infecting food used in the hotels in which the cases originated. However, the water department investigating other possibilities, found a possible source in the pollution of the hotels' water supply by a surcharged house sewer which could have leaked into a water tank containing cool water for drinking. A cross connection between the sewer and a condenser water tank also was considered as a possible source. If pollution of water supply was the cause, the reason given for the non-appearance of other diseases related to the ingestion of sewage polluted water was that the residual chlorine in the city water was sufficient at all times to destroy pathogenic bacteria in the minor amount of sewage that possibly entered the water system.

PIPE LOCATING EXPERIENCES WITH THE TERROMETER

By THOMAS L. AMISS

Superintendent, Dept. of Water and Sewerage, Shreveport, La.

As a result of considerable study to develop a suitable instrument for detecting the presence of metallic objects buried beneath ground surface, engineers of the Engineering Research Corporation of Shreveport, Louisiana, have successfully perfected an instrument known as the Terrometer. One of these instruments has been used in pipe location under the writer's supervision.

Briefly describing operation of this instrument: The Oscillator produces a high-frequency electro-magnetic field which not only reacts on the Detector but enters the earth and penetrates to a considerable depth. Initially the orientation of the Oscillator and Detector is such that, with no disturbing metallic mass in the neighborhood the instrument, a minute exciting current flows in the Detector circuits. The magnitude of the Detector excitation, which may be controlled by varying the angularity of the Oscillator, is so adjusted that approximately midscale deflection is indicated by the galvanometer connected to the output terminals of the Detector. If an electrically conductive mass now be brought within the effective range of the Oscillator field, then this mass causes a secondary field which reacts on the Detector circuits and thereby produces a change in the galvanometer reading.

The First Field

Now that you have some idea of the instrument and its work, I will supply a concrete example of its operation. The picture identified as Fig. 1 shows the operator in the act of locating a main, and Fig. 2 pictures the instrument knocked down for transportation.

The instrument was taken to a location, selected by myself, for a trial test. In a very few minutes the apparatus was assembled and ready for test. Of course, the batteries, tubes, etc., were known to be in working condition before leaving the office as would be necessary of any pipe locator. The instrument was operated under my supervision and also in the presence of my assistant, Mr. Cranmer, and our Superintendent of Construction and Maintenance, Mr. Reynolds. I selected the location for the trial test and when ready advised the operator to locate a 6 inch cast iron water main within 50 feet of where we were standing. It wasn't long before the in-

Fig 1.—Locating a Main

Fig. 2.—Instrument Knocked Down for Transportation

strument responded but somewhat off the line of the 6 inch pipe, and upon investigation we found an old, abandoned service pipe to an old fountain which I did not know of myself. However, by traversing a new field we soon made positive the location of the 6 inch main and these points were marked with 60 d. nails. I selected this location because the pipe was laid on a curve. When we completed the locations, which were at intervals of 10 to 20 feet, we verified the accuracy of the points by actually digging up and exposing the pipe. Other tests were made with the new Terrometer and the results were entirely satisfactory.

The simplicity of the machine and its operation immediately appeals to one who has had active charge of the supervision of a distribution system. I am of the opinion that one, after having used the Terrometer for a time, can become very expert in handling it, and by his skilled knowledge in operating it can effect a considerable saving to a department.

A Wireless Locater

As the pictures reveal, there are no wires to worry with nor connection points to make; one simply has to walk where he thinks the main is most likely to be. When reading the Detector dial, which is located directly in front of the operator, upon crossing the main the hand on the dial will immediately respond. To prove the location, the same operation is resorted to from another field some few feet from the first location and in the opposite direction. It will be found that in checking the first location you will spot a point very close to the first and the split difference between these two points is the true location of the pipe.

The size of the pipe and its depth has a bearing on the results obtained; this feature, however, is one that an operator will have to gain through experience.

I feel that dependable pipe locating equipment is well worth its cost because without a doubt the returns through the information obtained from its use will be many times the expenditure for the instrument.

In conclusion I wish to state that it appears that the Terrometer will do all that its producers claim and to the satisfaction of the user. Within the next year I hope to be able to give more definite information based on extended experience in its practical application.

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Bob Thieme Joins Ralph Stevenson on Pacific Coast

Ralph A. Stevenson and R. B. Thieme announce the organization of Stevenson-Thieme & Co., with offices in Los Angeles.

The new firm will represent International Filter Co. and National Meter Company in Southern California and Arizona and will supervise the operations of International Filter Co. on the entire Coast. In addition, it will distribute a complete line of chemicals for water purification and sewage treatment.

Ralph Stevenson is well known on the Pacific Coast as former Superintendent of the Sacramento Filtration Plant, and later Research Chemist for the Great Western Electro-Chemical Company. A year ago he started in business for himself as a jobber of chemicals for the water and sewage field. Steve's motto of *"Service with Sales"* has gained for him many boosters and success in his new enterprise.

Bob Thieme is also well known to the water works profession. For the past six years he has acted as Pacific Coast Manager for the International Filter Co., in which position he has made many friends for himself and his firm.

The new firm plans to gradually extend its line of equipment and materials to effectively and completely serve the water and sewage fields. Offices, shop and warehouse will be located at 2309 East Eighth street, Los Angeles.

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Water Shortage in 1934 in Ohio Bad as Three Years Ago

After the unprecedented drought of 1930 occurred, it was generally predicted that a drought of similar nature would not occur again for a generation. However, according to the Ohio Health News of Dec. 1, up to the date of this writing, a drought has again occurred which has, insofar as its effect on public water supplies in Ohio is concerned, been at least as severe and in many instances more severe than the 1930 drought. It is known that water shortages have occurred during 1934 in about 40 municipalities of the state; probably other cities and villages have also suffered similar experiences. The sad feature of this is that a number of cities and villages which suffered a water shortage during 1930 are again listed in 1934.

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COMMITTEE TO ELIMINATE STREAM POLLUTION.—A committee headed by George H. Dern, Secretary of War, was named Dec. 6 to draw up a coordinated Federal program to eliminate pollution from streams. In addition to the Secretary, those comprising it will be Dr. M. M. Ellis, of the United States Bureau of Fisheries; R. E. Tarbett, chief of the engineering section of the United States Public Health Service; Thorndike Saville, executive engineer of the water resources section, national resources board; Sanford H. Wadhams, director of the Connecticut State water commission; Grover C. Ladner, of Philadelphia, chairman of the water committee of the Pennsylvania Conservation Council, and Dr. D'Arcy Magee, of Washington, national vice-president of the Izaak Walton League.

EDITORIALS

How to Secure Needed Improvements In Water and Sewer Systems

IN 1932 there were only three states having laws that enabled municipalities to issue revenue bonds for building or improving waterworks and sewerage systems. Thanks largely to the educational efforts of the Portland Cement Association, the number of states now having such laws is 32. This is a remarkable achievement, but it will bear little economic fruit unless engineers, superintendents and other officials in charge of these utilities make known to the public that there is now available a splendid method of financing improvements and that there is either economic or other need of making them.

Although economic need of an improvement is often pressing, not infrequently a sanitary need is greater. This may not be easily shown to a public unacquainted with sanitary problems. But mere repetition of the statement that a sanitary need exists will usually win the public to belief in its desirability, provided that the statement comes from trustworthy sources and comes frequently enough.

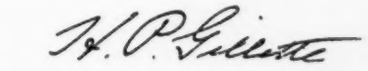
Newspaper reporters and editors are usually eager to convey to the public the opinions of men in responsible public positions. Where those men obviously have no personal ax to grind, they may thus become the most effective formers of public opinion.

The writer recalls that when he had just finished his engineering education he was instrumental in persuading nearly all the citizens of a "boom town" to abandon drinking well water and become patrons of a water company that was just finishing its plant. At that time there was a typhoid epidemic in the town, and few people knew the cause of typhoid. In a series of interviews that were published in a daily newspaper, the writer explained the then newly discovered cause of typhoid and how the typhoid bacillus reaches a well from a privy. The effect of this publicity was instantaneous. That town soon was rid of typhoid, because its people ceased drinking well water and began drinking the pure lake water that the company delivered to them. There has been no typhoid epidemic there to this day. Of course, some years later when chlorine was found to be so marvelously effective in killing germs, chlorination of the lake water ended forever any danger of a typhoid epidemic from contaminated water.

The point of this story is this: An engineer or other official of a municipality or of a company serving a municipality can and should teach the public what it really needs in the way of sanitary service; and he should not wait until his opinion is asked, but should volunteer it. Newspapers are almost invariably glad to give publicity to such opinions.

Coming back to the 32 states that have laws permitting the issuance of revenue bonds, how many of our readers know that they do or do not reside in one of those states? Is it not important that each of you should know not only that fact, but should resolve to give publicity to it? Furthermore, is it not highly important that you should use the newspapers to inform the public—not once but repeatedly—what improvements are urgently needed either in the waterworks or the sewerage systems or both?

Yours is the job of leading public opinion in such matters, and such leadership should not be pressed upon you. Yours is the duty to appoint yourself the leader, and not to quit until your object is attained.



Chemical Sewage Treatment Progresses

INTERMEDIATE degrees of sewage treatment which chemical-precipitation will provide whenever, and as frequently as, the necessity demands is beginning to be accorded its proper place in sewage treatment practice. Engineers who have adopted the policy of watchful-waiting in respect to chemical processes can not but be impressed with recent developments. Of more than commonplace interest to sanitation authorities, are the three recent decisions which recognize the adaptability and economic aspect of intermediate sewage treatment procurable with chemical methods.

The treatment selected some months ago for the 35 m.g.d. project to serve the Coney Island area of New York City involves chemical precipitation. The decision was based on the fact that the sewage may be given a higher seasonal purification than plain sedimentation provides, and with the least expenditure in terms of the degree of purification obtainable per dollar expended in plant, grounds, equipment and and treatment. The recent decision of the Minneapolis-St. Paul Sanitary District to employ plain sedimentation, supplemented by chemical precipitation as a seasonal requirement in place of biological secondary treatment, is of even greater moment because of the great size of the project (134 m.g.d.) and the more critical stream conditions below the Twin Cities than is the situation in New York's case. The District of Columbia authorities have almost simultaneously concluded, that if anything beyond plain sedimentation is to be required for the sewage of Washington and contiguous area, the adaptation of seasonal chemical treatment should prove sufficient and the most economical procedure, rather than the building of a biological plant.

A type of chemical precipitation which has been in use at Winston-Salem, N. C., for several years seems about to be improved by a method under development there. Dearborn, Mich., 3 years ago, was the first of the newer plants to make use of ferric iron coagulation and effluent filtration. Then followed the Plainfield, N. J., plant and that at Gastonia, N. C., which adapted partial chemical precipitation with ferric salts to increase removals of organic solids in the primary sedimentation tanks and thereby relieve loadings on biological secondary units. Birmingham, Ala., selected chemical precipitation in 1933, after some months of experimentation, and now has 6 months of satisfactory operating results to indicate the feasibility, dependability and economics of its

project. York, Neb.; Perth Amboy, N. J.; San Luis Obispo, Calif.; Raleigh, N. C.; Elmira and Niagara Falls, N. Y., and other municipalities have chemical treatment schemes completed or in some stage of development.

In providing sewage treatment for municipalities there is one major question to be decided by the authority charged with recommendation or selection of the process to be employed, viz.: the *degree of treatment* required to maintain the receiving water in a satisfactory condition. The next question is: How most economically to secure an effluent which at all seasons will meet these requirements. The latter involves taking into account fixed charges against the required plant and likewise maintenance and operating costs of the process under consideration. When one reaches a decision based on these major requirements, it is possible that the method of treatment may not appear ideal nor expensively refined. The effluent may not have the sparkle that is so pleasing to the eye, but hard on the municipal pocket book.

There being a decided trend in the direction of municipal economy, and with the P.W.A. playing a controlling hand over the use of government relief money for sewage treatment projects, it will be required that the cloth of municipal waste disposal be trimmed to a neat fit, leaving embellishments for a later day. There will be more homespun and less silk-stocking sewage treatment for the present, at least.

There are numerous cases where 33 to 40 per cent treatment by sedimentation will suffice for much of the time, with added chlorination to raise this figure to 55 to 60 per cent, and chemical precipitation to step up purification to 75 or 80 per cent during periods when stream conditions justify. The cost of treatment will thereby be put on a sliding scale and becomes a charge against performance demanded rather than the demanded performance of other less flexible processes. Although the fairly easily upset activated sludge process requires careful control in many cases if it is to be kept on an even keel without recourse to the use of the most indispensable adjunct to such plants—the bypass gate—it is not perhaps as simple to procure continuously efficient chemical precipitation as some might imagine. Properly coagulating sewages and tradewastes, or mixtures of both, is not as easily attained as coagulating potable waters. The variables, such as flow, alkalinity and organic make-up of sewages must be taken into account and the chemical feed adjusted as need be to meet these changes if effective precipitation is to result without waste of materials. Further, attention to effective pH control, mixing, and flocculatng devices is more important by far in sewage treatment, both as to efficiency and economy of performance. Chemical treatment must, for best and most dependable results, at least be supervised by a trained chemist or an engineer with a sufficient chemical background to understand the chemistry of coagulation, the handling of chemicals, and the means of insuring adequate and economical performance from chemical processes. With this equipment the operator will be able to adjust the process to meet changes or correct ineffectual treatment within a short period after the difficulty arises—something far less easily attainable with the biological processes which often requires days as compared with minutes or hours for chemical process adjustment.

The Minneapolis-St. Paul authorities in their recommended trial of chemical precipitation weighed the additional investment of almost $2,000,000 required and the extra $124,000 per year costs, as fixed and operating charges, to provide a combination involving biological treatment of as little as 33 per cent of the whole of the flow; as being too important to overlook. They strike a key-note when they argue that "In case it (chemical precipitation) fails to measure up to expectations in the future, no part of the investment (in plant) will be lost, as it will form a useful part of method (2)," viz.: the combination of chemical and biological treatment under consideration.

With certainty, such a statement has a degree of soundness that deserves more than passing attention.

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The Southwest Section

IT will be of great satisfaction to every member of the American Water Works Association to learn of the decision of the Southwest Water Works Association to consolidate with the American as its Southwest Section.

Organized in 1912, the Southwest Association has been built up by such leaders as its "Grand Old Man of Water Works," Jesse Shaw, Superintendent of Water at Tyler, Texas; "Vic" M. Ehlers, the pioneering Sanitary Engineer of Texas' State Board of Health, who during many changes in Texas administrations has stood like the "solid rock" that he is; Egmont Smith, Southwest Manager for Neptune Meter Co., and "Mat" Collins, Southwest Manager for Rensselaer Valve Co., and others.

The virile Southwest Association has received repeated overtures from the American to join forces with it for the general good of both. But each time its decision has been against a consolidation, on grounds best known to its Directors. Through its recent decision no prestige has been sacrificed, there being no evidence of a weakening of the Association. In fact, the Southwest group has continued to grow and to become the more coveted by the National Association. Many of the oldsters held to the opinion that there was nothing to be gained by the consolidation. But the younger members and many of the older members (already members of the National Association) converted the objectors, and the vote of the recent Southwest Convention to consolidate was unanimous, save one "No" from the "Grand Old Man of Water Works," who is as sincere in his convictions as he was in his valued services in building up the Association of which he is Honorary member and which he twice served as President.

The Southwest Association has recently held its 23rd Annual Convention in Waco, Texas. It represents six states—Arkansas, Kansas, Louisiana, Missouri, Oklahoma and Texas—and is governed by a board composed of a State Governor from each. Under the leadership of its retiring President, W. H. Vaughan of Fort Smith, Ark., this Board put into form numerous constructive measures. Under the leadership of its new President, John B. Winder of Dallas, Texas, this program will go forward to cause the new Southwest Section to blossom to its fullest.

American's lusty "baby" Section comes to it already of "bronco-busting" age, to add strength to both Associations. We salute the newest Section of the A. W. W. A.—one truly representative of the Great Southwest.

L. H. Enslow.

NEW EQUIPMENT AND LITERATURE

Improved Pipe Thawing Equipment by Darley

(Features Low Voltage-High Amperage)

In our November issue there appeared on page 8 an ad descriptive of a new development in electrical pipe thawing equipment by W. S. Darley & Co.—a Chicago firm of long experience in the water works equipment field.

The new readily portable, low-cost thawer has many novel features; is light in weight (550 lbs.), but sturdily constructed. The air cooled gasoline motor has a speed regulator for varying the generator output from 440 amperes (at 16 volts to 26 volts) upwards to 880 amperes at 8 volts—or, if needed, 950 amperes at 13 volts. This flexibility of low to high amperage (*at low non-dangerous voltages*) is new and of importance in pipe thawing with electrical equipment. Speed of thawing, with safety to operators and freedom from damage at pipe joints, is thereby assured.

A new and fully descriptive illustrated catalog has just been issued on this and other equipment by W. S. Darley & Co., 2810 Washington Blvd., Chicago. Ask for Catalog No. 100—"Pipe Thawing Equipment."

▼

Improved Sludge Pump

The Chicago Screw-Feed Centrifugal Sludge Pump was first described in our New Equipment Section very shortly after it was introduced into the sewerage field. To the early models, improvements and refinements have been added—some in recent months. Its performance and the growing number of satisfied users warrants this further description.

The cutting and conveyor attachment (the screw) keyed to the shaft ahead of the specially designed open impeller of this centrifugal pump constitutes the feature which makes it positive in action and non-clogging. Of mechanical interest, this is accomplished with a *single* revolving member. Starting with the basic principle of screw-feed, so effective in cutting up troublesome materials found in crude sludge, further developments have added materially to its adaptability.

For the important function of regulating the rate of sludge transfer the improved motor and pump assembly incorporates a Varidrive motor equipped with a micro-speed control wheel which appears at the left base of the unit above illustrated. A turn of the wheel forces the motor toward or away from the pumps. As the motor is moved back the pump speed drops off due to the V-type belt forcing the pulley faces apart and consequently running on an increasingly smaller diameter pulley. An indicator at the base of the motor reveals the various pump discharge rates for all of the multiple settings of the motor. The unit can also be made to vary its output automatically to meet varying rates of sludge accumulation that must be moved. The variations in discharge are from a gallon or two a minute to full pump capacity, which is attained within a 35 per cent range in pump speed variation.

Where sludge can not be gotten to the pump by gravity, thus requiring a lift, a self-priming attachment is provided. Where it is not necessary to vary the rates of sludge pumping a constant speed or a two-speed motor, direct connected to the pump, fills all of the requirements. The latter may be operated intermittently for desired durations by time-clock control or through a sludge depth gage which automatically starts and stops the motor. The manufacturer guarantees that these units will economically and satisfactorily pump crude sludges under any condition which may have to be met—experience being based on a variety of successful installations.

A new bulletin 124-D—"Sludge Pumps"—illustrates and describes the several Chicago Screw-Feed Sludge Pump assemblies and outlines conditions for which designed. For a copy, address Chicago Pump Co., 2336 Wolfram St., Chicago.

Chicago Screw-Feed Centrifugal Sludge Pump

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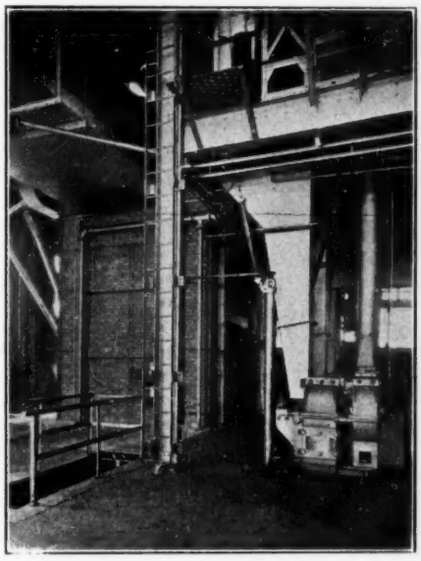
Chicago Finds Sludge Incineration Both Practical and Economical

Successful incineration of sewage sludge, a desideratum of sanitary engineers for years, now seems to be thoroughly demonstrated as a practical and economical method of disposal.



Chicago Dryers and Incinerator

Tests and demonstrations at Chicago have led the Sanitary District authorities to turn to mechanical dewatering and incineration of undigested solids in its projected sewage treatment program, as the most efficient means of sludge disposal.

The Chicago authorities have been experimenting with sludge drying and incineration for the past several years and now consider it as the most satisfactory all around method of *complete disposal* and a process void of nuisances or hazards to health. The system to be employed starts with the coagulation and dewatering of the fluid sludges on vacuum filters. The sludge cake from the filters is mixed with previously dried sludge and put through a dryer and then a pulverizer. The disintegrated sludge, with some added fuel when required, is blown into the incinerator and burned in suspension. The

disposal of the sterile inorganic ash constitutes no particular problem and the whole process represents disposal, *in fact*, of the most objectionable parts of sewage —the organic solids.

At Chicago, the Raymond "flash-drying" system and Raymond pulverizers (for many years widely recognized in the industrial and power plant fields) have been successfully adapted to prepare the sludge cake, produced from the Oliver vacuum filters, for incineration.

The Raymond Impact Pulverizer Co. is a division of Combustion Engineering Co. of New York City, which has just recently entered the sewage field and is preparing to offer sludge drying and incinerating equipment to meet guaranteed performance specifications.

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Arrowhead Gratings

Sometimes, it all depends on how you look at things! The above picture is one illustration of such a case. Turned upside down it is a view (looking up) through one section of the Arrowhead grating and step-treds in the recently completed York, Neb., chemical-precipitation sewage treatment plant, designed by Black and Veatch, of Kansas City. One hardly expects to find dignity and beauty in a sewage plant grating, but the reader can pass on this feature of the Arrowhead design by merely looking at the picture. The claim of the manufacturer concerning maximum light transmission and ventilation is likewise evident.

The real reason for the Arrowhead design, however, is an engineering reason—it is at once light and strong because of the full-truss principle utilized in the design as illustrated by the inset sketch above. The combination of lateral and oblique bracings makes rigid construction possible with thin strips and light weight load carrying bars. The manufacturer is thereby able to claim that Arrowhead is the strongest of the gratings (specifications being equal) and also the lightest in weight for specified load capacities. The Arrowhead design and construction, with square edged riveted steel strips and bars, provides a resiliant and non-skid floor in all directions and a foot-safe step tread. Further, it is classed as a self-cleaning as well as a safety grating.

A Picture in Reverse

In the industrial and architectural fields Arrowhead Gratings have been used for 15 years; have been used at several recently built sewage plants. Heavily (hot-dip) galvanized, they resist corrosion.

An attractively illustrated bulletin which includes design and specification data also, has just been received and is responsible for this item. For a copy of "Arrowhead Gratings" address Arrowhead Iron Works, 421-31 West 5th St., Kansas City, Mo.

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Everdur Metal in Sewage Treatment

Machinery and equipment at sewage treatment works is exposed constantly to varying degrees of corrosive attack. It is important, therefore, to select and specify construction materials that will meet both engineering and chemical requirements satisfactorily.

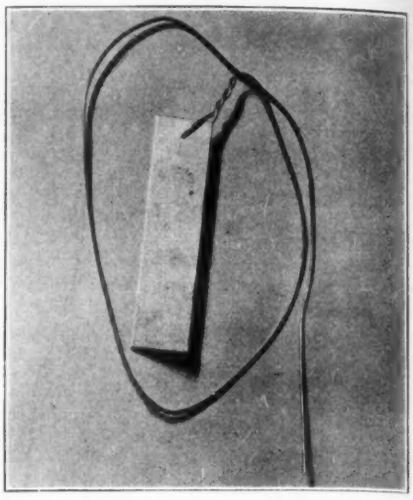
Everdur-Metal, a high strength copper alloy with an unusual combination of properties, has had a growing application at sewage treatment plants, and is regarded by a number of sanitary engineers as the most useful all-purpose metal yet available for use in sewage disposal equipment. It has given satisfactory service in various sewage disposal plants since 1927, but its more extended use has come within the last three years.

Everdur is in reality copper which is strengthened and toughened and made weld-able by the addition of silicon and other elements. It possesses the tensile strength of medium carbon steel, the ductility of Swedish iron, and surpasses copper in corrosion resistance. It welds as readily as steel—by both gas and electric arc methods—and this property has made possible many economies in the design and assembly of varied equipment from Everdur. Light-weight swing and slide gates of welded light Everdur sheet construction have been installed in several plants to replace heavy cast metal gates formerly used.

Five years of service in the form of screen plates, held in place by Everdur bolts on Reinch-Wurl type screens, has demonstrated its resistance to corrosion and wear when compared to the high strength bronze which failed. Lack of grit chambers, presence of corrosive industrial wastes and the sulphide content of the sewage has constituted a severe test on the Everdur plates and bolts.

Other Everdur equipment which has been used in various plants include coarse and fine screens, swing gates, built-up sluice gates, coarse bar rack aprons, effluent weirs and scum weirs, structural scum baffle brackets, troughs, screen hoppers, orifices, baskets, anchors, ladders, float gauge chain, valve stems and springs, manhole steps, guides, walkways, bars and plates, bolts and nuts.

The American Brass Co. has prepared test samples of Everdur which are available to plant superintendents or engineers. These test pieces are offered for the purpose of testing the resistance of Everdur to corrosion or comparing its qualities with that of other metals or alloys.



Test Strings

The test pieces are drilled at one end so that the sample may be suspended where desired. The American Brass Co. of Waterbury, Conn., will send one or more test pieces and their bulletin on Everdur in sewage treatment to anyone interested in the resistance of Everdur to corrosion and its applications as now known in the sewage field.

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Morris Double Suction Pumps

Morris Machine Works, originators of the centrifugal type pump 70 years ago and the oldest American manufacturers of centrifugal pumps, have recently published a bulletin describing Morris Double Suction Horizontally Split Centrifugal Pumps.

The bulletin outlines the important advances in centrifugal pump design which within the last few years have vastly improved the efficiencies obtainable with this type of pump and details of Morris design, which characterizes their present standard double-suction split-case pumps, are explained.

A section of the bulletin deals with precautions that should be taken in the installation and operation of centrifugal pumps and diagnoses the most common causes of service interruption. Engineers and operators will find this section of particular interest.

Copies of Bulletin 152 may be obtained by addressing Morris Machine Works, Baldwinsville, New York.

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Enduro Stainless Steel Now Carried in Stock at 45 Points

Appointment of three new warehouse distributors of *Enduro Stainless Steel*, making 45 such distributors in principal cities, has been announced by N. J. Clarke, vice-president in charge of sales, Republic Steel Corp., Youngstown, Ohio. The new distributors are: Buhl Sons Co., Detroit, Mich.; F. W. Heitmann Co., Houston, Texas; and The Woodward Co., Albany, N. Y.

Water Works and Sewerage

Design-Construction-Collection-Treatment-Distribution-Disposal

INDEX

Vol. LXXXI, January-December, 1934

GENERAL INDEX

A

Activated Alum, Results from Use at Batavia, N. Y. 47
Activated Carbon, Method of Applying ... 184
Activated Sludge, Case Milwaukee Loses.. 77
Activated Sludge Patent, Court Decision.. 383
Activated Sludge Patent, Tenefly, N. J. Settlement 345
Activated Sludge Plant, Lancaster, Pa.... 7
Activated Sludge, Symposium on 125
Advertising the Water Utility.....363, 395
Aerator, Novel Mechanical (Chicago).... 396
Aeration of Sewage, Methods for 27
Aerators 27
Algae Growths, Copper Sulphate Treatment 133
Algae Growth Raises pH of Water..... 275
Alum, Activated, Use at Batavia, N. Y... 47
Alum Feeder 183
American Water Works Association, 54th Convention 244
American Water Works Association, Program 54th Convention 100
Amoebic Dysentery, Chicago, Cause of... 251
Aqueduct, Los Angeles, 20th Anniversary. 21
A.S.C.E., Sanitary Engineering Division Meeting 58
Atmospheric Contamination by Sewage Works 123
Awards, Value of 70
A.W.W.A. Convention, Digest of Papers .. 290

B

Bacterial Baskets 185
Batavia, N. Y., Use of Activated Alum... 47
"Black Alum" Results from Use at Trenton, N. J. 213
Blowers, Centrifugal, Roots-Connersville.. 362
Bruckner Cycle and Present Drought 188
Burnt Mills, Md., Water Purification Plant 179

C

California Section A.W.W.A. 15th Convention 385
California Sewage Works Association Meeting 280
Cannery Waste Treatment in Wisconsin. 346
Cast Iron Pipe in Sewer Construction 23
Cast Iron Sewer, Friction Coefficient 220
Central States Section A.W.W.A., Meeting of 315
Chemical Application, Emergency Devices for 183
Chemical Feeder, W. & T. New 170
Chemicals, Mixing Under Pressure 184
Chemical Precipitation Plant, Operating Results, Chicago 52
Chemical Sewage Treatment Plant, Dearborn, Mich., Performance 87
Chemical Sewage Treatment Progresses .. 423
Chemical Treatment, Flow Diagrams for.. 65
Chemists, Value of 104
Chloramines in Water Purification 31
Chlor-O-Feeder 262
Chlorine, Applied Direct from Cylinders to Reservoirs 184
Chlorine Containers, Lift Trucks for 71
Chlorine in Water Purification 31
Chlorinated Copperas, Experience at Dallas, Tex., as Coagulant 73
Chlorinating, Reducing Cost of..... 25
Chlorination, Control, Los Angeles 297
Chlorination of Sewage 343
Chlorination in Sewage Disposal A.P.H.A. Committee Report Discussed 133
Chlorination of Sewage, Partial vs. Complete 124
Chlorination in Sewage Treatment 90
Chlorination, Symposium, A.W.W.A. Convention 256
Chlorinators, Water Heater for 186
Coagulant, Chlorinated Copperas As 73
Coagulant Dosages, Stirring Apparatus for Determination of 358
Coagulation with Iron Compounds 252
Coagulation, Ferric Sulphate, Providence, R. I. 229
Coal Mines, Abandoned, Sealing 99
Code of Water Supply Industry 69
Cold Weather and Water Supply Problems 105
Compartment Type Mixer, Dual Flow ... 45
Controller, Foxboro Rotax 330
Conventions, Importance of Attending 169
Copper Sulphate, Method of Applying, Baltimore, Md. 135
Corrosion of Well Casings by Electrolysis 112
Curb Boxes, Locking Device for 34

D

Dearborn, Mich., Chemical Sewage Treatment Plant 87
Dechlorination of Superchlorinated Water with Magnesium Metal 241
Deflector Nozzles, F.F.T. 330
De Lavaud Pipe, Super..... 55
Diesel Engine, Sterling Crankless 106
Diffuser Mediums, Porous Air, Installation and Servicing 115
Digester Overflow Liquor Character and Effect on Plant Operation 51
Distribution "Kinks" 187
Distribution System, Determining Deterioration of 408, 410
Drought and Bruckner Cycle 188
Dorrco Equipment, 30th Anniversary 267
Dual Flow Compartment Type Mixer 45

E

"Electric Eye" in Sewage Treatment Plant Control 214
Electrolysis, Corrosion of Well Casings by 112
Editorials 35, 36
69, 104, 137, 169, 228, 260, 294, 329, 395

F

Feed Devices, Emergency Solution 183
Fences, Stewart 295
Fermentation Tubes, Numbering 185
Ferric Chloride "Isco" Hand Book..... 295
Ferric Chloride for Removal of Color from Textile Wastes 19
Ferric Chloride, Rubber Lined Equipment for 170
Ferric Sulphate Coagulation, Providence, R. I. 229
Field Joints for Large Steel Pipe 397
Filter Bottoms, New (Aloxite) 396
Filter Plants, New Rate Controller for ... 310
Filtering Materials, Study for Rapid Sand Filers 127, 162, 352
Filters, Eliminating Air in 154
Filters, Old Tube, Controlling Filtration Rate 186
Filters, Rapid Sand, Filtering Materials for 127, 162, 352
Filters, Reconditioning 48
Filtration Plans, Flow Diagrams for Chemical Treatment 65
Filtration Plant, Burnt Mills, Md. 179
Filtration Plant, Handling Sugar Beet Wastes 61
Fire Protection Charges for Municipal Water Works 324
Flow Diagrams for Chemical Treatment and Filtration of Water 65
Friction Coefficient of 30 Year Cast Iron Sewers 220
Frozen Service Pipes, Thawing 369
Fuller, George W., Death of 235

G

Gas Engines, Operating Experiences, Grand Rapids, Mich. 300
Gas Indicator, U. C. C. 72
Gate Valves, Inserting Under Pressure ... 212
Green Bay, Sewerage Construction 387
Grit Chamber, Portable, Facilitates Sewer Cleaning 384

H

Herington, Kans., Reclamation of Sewage 177, 331
Hetch Hetchy Water Delivered to San Francisco 394
Hourly Load Variations Factor in Sewage Treatment Plant Operation 237
Hydrant, Crispin 71
Hydrants, Charges for 324
Hydrants, Columbian 262
Hydrant and Valve Inspection, North Andover, Mass. .....
Hydrants, Spacing of 338
Hydrants, Thawing 187
Hydraulics, Practical 119, 216
Hydrogen Sulphide Damages Oklahoma City Sewers 333

I

Incineration of Sludge 20
Intake Troubles, Recording Depth Gauge Warns of 64

J

Johannesburg, S. Africa, Sewage Treatment 373
Johnson, George A., Death of 114
Joints, Field, for Large Steel Pipes 397

K

Kiersted, Wynkoop, Death of 383
Kinks, Distribution System 187
"Kinks," Laboratory 185
"Kinks," Plant Equipment 186
"Kinks," Water Works 183
Krolite, A New Metal Preserver 330

L

Laboratory "Kinks" 185
Laboratories, Water and Sewage, Equipment for 151
Lancaster, Pa., Unusual Features of Sewage Treatment Works..... 7
Lehigh Valley R. R., Wayside Water Treatment 11
Licensing Operators, Value of..... 329
Load Variations, Hourly, Factor in Treatment Plant Operation..... 237
Locking Device for Curb Boxes..... 34
London, Water Supply..... 217
Los Angeles Aqueduct, 20th Anniversary.. 21
Los Angeles Water Supply, Quality of.... 297

M

Magnesium Metal, Treating Water with.. 241
Mains, Determining Deterioration of..408, 410
Meters, Battery, Installing..... 381
Meter, Gas, Sewage Disposal Plants..... 72
Meter Inspection, Newton, Mass..... 179
Meter Parts, Metal, Cleaning 187
Meter, Selecting Right..... 303
Meter Shop Practice, Newton, Mass..... 174
Michigan Sewage Works Association, 10th Conference 147
Mines, Coal, Abandoned, Sealing..... 99
Mixer, Compartment Type, Dual Flow.... 45
Morris Dam, Pasadena, Dedicated..... 233
Morris Dam, Unique Pump Installation... 360

N

New England Water Works Association, 53rd Convention 334
New England Sewage Works Association, Meeting 223
New England Water Works Assoc., Value of 312
New Jersey Sewage Works Association, 29th Meeting 121
New Equipment .....
..71, 106, 138, 170, 262, 295, 330, 362, 396
New York State Sewage Works Association, Jamestown, N. Y., Meeting..... 259
N. Y. State Sewage Works Association, Meeting 372
N. Y. State Sewage Works Association, Winter Meeting 49
North Carolina Section A. W. W. A., Meeting 19
North Carolina Sewage Works Association, Meeting 19

O

Odor Control with Ferric Chloride..... 124
Odor Detector, Inexpensive..... 351
Odor and Taste Control, Trend of..... 327
Ohio Conference in Sewage Treatment ... 414
Ohio Conference on Water Purification .. 419
Operators' Licensing Laws..... 329

P

Paint, "Triple-A" Aluminum..... 362
Paris, France, Water Supply of..... 380
Pennsylvania Sewage Works Association, 8th Conference 288
Pennsylvania Water Works Operators Association, 7th Conference..... 283
Pipe, Cast Iron, in Sewer Construction... 23
Pipe Line Friction..... 335
Pipe, Locating with Terrometer 422
Pipe, Steel, Field Joints for 397
Pipe, Super-De Lavaud..... 55
Pipe Thawing Generators, G. E..... 138
Pipe Tuberculation 340
Pipe, Vitrified, Extra Strength, Used at Los Angeles 391
Pipe Wrench, Trimo..... 138
Plant Equipment, "Kinks"..... 186
Pneumatic Conveying Soda Ash, Columbus, O. 84
Porous Air Diffuser Mediums, Installation and Servicing 115
Protective Coatings Applied to Large Water Mains 171
Prüss Pump, Operation at Baltimore Sewage Works 78
Pump Discharge Lines, Eliminating Surge Troubles in 145
Pump Installation, Unique, Morris Dam.. 360
Pump, Prüss, Operation at Baltimore Sewage Works 78
Pumping, Sewage, Evolution at Norfolk, Va. 131
Pumping Station, Surge Suppressors for, Croton Lake, N. Y..... 207
Pumps, Economy Non-Clogging..... 330
Pumps, Prime, "Rex" Speed..... 362
Pumps, Sewage, Low Head, Operated with High Speed Motors..... 86

Pumps, Worthington Monobloc..... 296
Public Relations Activities for Water Utility 363
Purification, Water, Progress in 1933..... 1
PWA Accomplishments 336

R

Railroad Water Treatment, Lehigh Valley R. R. 11
Rapid Sand Filters, Study of Filtering Materials 127, 162, 352
Rate Controller, New, for Filter Plants.. 310
Recording Depth Gauge Warns of Intake Troubles 64
Reservoir Water, Clarifying with Alum.. 184
Reservoirs and Recreation..... 260
Reynolds, M. B., Death of..... 60

S

Sampler, Water, Atlanta 101
Sanitary Engineering Division, A. S. C. E., Meeting 58
Sealing Abandoned Coal Mines..... 99
Self Supporting Utilities..... 361
Separate Sludge Digestion, Special Design for 148
Service Pipes, Action of Water on..... 338
Service Pipes, Frozen, Thawing..... 369
Sewage Aeration, Methods 27
Sewage, Chlorination of..... 343
Sewage Disinfection with Chlorine..... 223
Sewage Disposal, Chlorination in..... 133
Sewage Effluent Used for Chlorinator Operation 25
Sewage Plant Operation, Improving at Springfield, Mo. 322
Sewage Pump Installation, Wingdale, N. Y. 267
Sewage Pump, Non-Clog Enclosed Impeller 72
Sewage Pumping, Evolution at Norfolk, Va. 131
Sewage Pumps, Low Head, Operated with High Speed Motors..... 86
Sewage Treatment, Ohio Conference 414
Sewage Reclamation, Herington, Kan..... 331
Sewage Screen and Shredder, Chicago Comminutor 295
Sewage Sludge, Dewatering by Vacuum Filters, Hagerstown, Md..... 139
Sewage Sludge, New Device for Removing 57
Sewage Treatment Plant, Chemical, Dearborn, Mich., Performance..... 87
Sewage Treatment, Chlorination in..... 96
Sewage Treatment Plant Control, Electric Eye in 214
Sewage Treatment Plant Operation, Hourly Load Variations Factor 237
Sewage Treatment, Johannesburg, South Africa 373
Sewage Treatment, Recent Development.. 16
Sewage Treatment, Recent Developments in Germany 225
Sewage Treatment, Developments in 1933 39
Sewage Treatment, Reduction of Supernatant Liquor Improves Operation.... 107
Sewage Treatment Works, Unusual Features, Lancaster, Pa..... 7
Sewage, Utilization, Herington, Kan. 177
Sewage Works, Atmospheric Contamination by 123
Sewer, Cast Iron, Friction Coefficient After 30 Years' Service..... 220
Sewer Construction, Cast Iron Pipe in.... 23
Sewer Construction, New Development... 391
Sewer Deep Open Cut of Unique Construction 313
Sewer Pipe, Extra Strength, Vitrified, Los Angeles 391
Sewerage Construction, Green Bay, Wis... 387
Sewerage, Developments in 1933..... 39
Sewerage Equipment of Yesterday and Today 189
Sight Well for Filtered Water..... 186
Sludge Dewatering, Baltimore, Md. 403
Sludge Dewatering, Mechanical, Economies of 272
Sludge Digestor Gas As Fuel for Small Gas Engines 300
Sludge Digestion, Dewatering, Digestion, Economies of 268
Sludge Digestion, Separate, Special Design for 148
Sludge Digestion: To Mix or Not to Mix 105
Sludge Disintegrator, Roger..... 138
Sludge Disposal Methods, Evaluating Costs of 268
Sludge Disposal by Vacuum Filtration and Incineration 20
Sludge Drying, New Method..... 210
Sludge Drying, New Method, Plainfield, N. J. 122
Sludge as Fertilizer..... 374
Sludge Gas, Utilitarian..... 70
Sludge, Increasing Salability of..... 277
Sludge, Measuring in Basins..... 186
Sludge Thickening, Phoenix, Ariz..... 107
Sludge Thickening, Progress in..... 137
Soda Ash, Device for Applying Under Pressure 183
Soda Ash, Pneumatic Conveyor System, Columbus, O. 84
Southeastern Section A. W. W. A. Meeting 155
Southwest Water Works Association, 23rd Convention 376
Spray Drying for Sludge, Plainfield, N. J. 210
Sprinkling Rates, Special..... 260
Sprinkling, Rules and Regulations..... 382
Steel Pipe, Field Joints for 397
Stirring Apparatus for Coagulant Dosages 358
Stream Pollution, Industry Should Pay for 137
Sugar Beet Wastes, Handling in Dundee, Mich., Filtration Plant..... 61
Super-De Lavaud Pipe..... 55
Surge Suppressors, Croton Lake, N. Y., Pumping Station 207
Surge Troubles, Eliminating, Washington, D. C. 145

T

Taste and Odor Control, Trend of..... 327
Tastes in Water Purification..... 31
Terrometer, Locating Pipe with 422
Textile Wastes, Removal of Color with Ferric Chloride 19
Thawing Frozen Service Pipes..... 369
Thermostats, Bearing, E. C. & M..... 71
Titration Unit, Novel, Phipps & Bird..... 71
Trade Literature, Review of..... 36
Turbidity, Measuring 185

U

Underground Flows, Tracing..... 379
Utilities, Self Supporting..... 361

V

Vacuum Filters Dewater Sewage Sludge at Hagerstown, Md. 139
Valve and Hydrant Inspection, North Andover, Mass. 103
Valve, Roto 106
Virginia Section, A. W. W. A., First Meeting 305
Virginia Water and Sewage Works Association, Meeting 15

W

Waste Treatment, Cannery, in Wisconsin 346
Wastes, Sugar Beet, Handling in City Water Plant 61
Water and Sewer System, How to Secure Needed Improvements 423
Water Consumption in Northeastern New Jersey 158
Water Hammer, Eliminating..... 145
Water Level Control, "Roto-Trol"..... 296
Water Mains, Cleaning, New York City.. 171
Water Mains, Large, Reconditioning, New York City 171
Water Plant Improvement, Self Liquidating 84
Water Purification, Papers Presented at A. W. W. A. Convention..... 254
Water Purification, Michigan Conference.. 357
Water Purification, Ohio Conference 419
Water Purification Plant, New, Ottumwa, Iowa 92
Water Purification, Progress in 1933..... 1
Water Purification, Tastes, Chlorine and Chloramines in 31
Water Purification Works, Burnt Mills, Md. 179
Water Sampler, Atlanta..... 101
Water Softening, Municipal, Recent Developments 263
Water Softening, Municipal, by Zeolites.. 153
Water Softening, Selling..... 294
Water Supply Industry, Code of..... 69
Water Supply, Los Angeles, Quality of... 297
Water Supply, Progress in 1933..... 1
Water Tanks, Elevated, Wrecking..... 218
Water Treatment, Lehigh Valley R. R.... 11
Water Works Equipment, of Yesterday and Today 189
Water Works "Kinks"..... 183
Weir, End Contractions of..... 216
Weir, Sharp Crest..... 119
Well Casings, Corrosion by Electrolysis... 112
West Virginia Water Purification Conference 315
Whitener, J. S., Death of..... 390
Wrecking Elevated Water Tanks..... 218

Z

Zeolite Water Softening, Cost..... 265
Zeolites in Municipal Water Softening.... 153

AUTHORS INDEX

A

Agar, Charles C..... 384
Allen, J. W..... 101
Amiss, Thomas L. 422

B

Babbitt, Harold E..... 27
Bach, Herman 241
Ball, Norman Z..... 131
Baylis, John R.....65, 127, 162, 254, 352
Bean, Elwood L..... 229
Behrman, A. S.....153, 263
Billings, L. C..... 73
Brown, Horace A..... 92
Brush, William W..... 171
Burch, L. R. 410
Buswell, A. M..... 87

C

Capen, Jr., Charles H.....31, 158, 324
Cardillo, J. V..... 11
Carollo, John A. 408
Cook, Herbert M..... 47
Cramer, Clark 183
Cranch, E. T..... 34
Curd, W. C. 397

D

Daniels, P. N..... 277
Donaldson, Wellington 139
Donohue, Jerry 387
Downes, John R..... 210
Duffy, W. B..... 103

E

Eddy, Harrison P..... 39
Eisert, W. L..... 363
Ellis, Richard H..... 174
Emigh, William C..... 275
Estey, Roger W..... 303

F

Ferguson, Harry F..... 268
Fuhrman, Ralph E..... 322

G

Gillette, Halbert P..... 188
Goudey, R. F..... 297
Greely, Samuel A..... 272

H

Hatch, B. F..... 99
Hechmer, Carl A..... 218
Hendon, H. H..... 23
Hoffman, Floyd A..... 214
Holton, Jr., Philip J..... 229
Hoover, Charles P..... 84

J

Jacobson, E. E..... 183
Jordan, H. E..... 1

K

Keefer, C. E..... 78
Keefer, C. E. 403
Kerr, S. Logan..... 207
Killam, Elson T..... 237

L

Laborn, J. F..... 7
Leipold, Carl 64, 154
Loreaux, W. D..... 61

M

Menke, Harry G..... 45
Morse, Robert B..... 179

N

Newsom, Reeves J..... 369

P

Potter, Alexander 220
Powell, Sheppard T..... 112
Priester, Max U..... 48

R

Radcliffe, D. M..... 145
Rawn, A. M.....96, 391
Reid, Joseph Y..... 213
Riddick, Thomas M.....151, 358
Roe, Frank C..... 115
Rudolfs, Willem 343
Rumsey, James R..... 300

S

Smith, Paul 135
Stapley, Edward R..... 313
Stover, E. Frank..... 310
Streithof, Charles 212
Stuart, F. E.....327, 351

T

Taylor, Henry W..... 148
Travaini, D. 107

V

Veatch, Jr., N. T..... 177
Velzey, C. R..... 272
Vivian, C. H..... 25

W

Walraven, W. B..... 57
Warrick, L. F..... 346
Weir, Paul 101
White, J. E..... 7
Wilson, P. S.....119, 216
Wisely, W. Homer..... 268

Y

Yeomans, Charles 86

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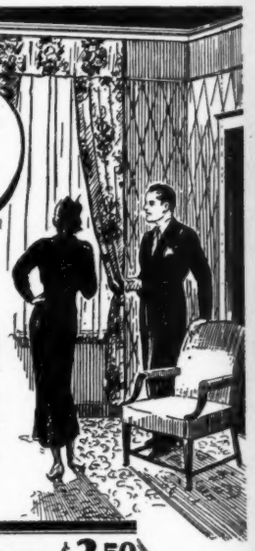

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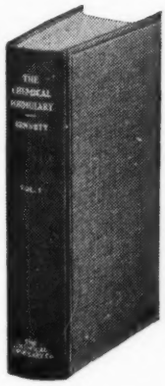

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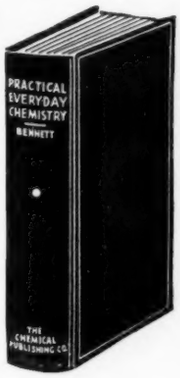

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A

Abrams Aerial Survey Corp. ... 48
Alvord, Burdick & Howson ... 48
Arrowhead Iron Works ... 8
Atlas Mineral Products Co., The ... 47
Auditorium Hotel ... 46

B

Baker, C. M. ... 48
Belle Alkali Co. ... 45
Bellevue Stratford Hotel ... 49
Black & Veatch ... 48
Builders Iron Foundry ... 10
Burns & McDonnell ... 48

C

Caldwell Co., Geo. A. ... 46
Cast Iron Pipe Research Asso., The ... 7
Chain Belt Co. ... Second Cover
Chester Engrs., The J. N. ... 48
Chicago Pump Co. ... 9
Chicago Testing Laboratory, Inc. ... 48
Cleveland, H. Burdett ... 48
Combustion Engineering Co., Inc. ... 5

D

Dixon, G. Gale ... 48

E

Edson Corporation, The ... 46
Engineering Research Corp. ... 11

F

Filclor Company, The ... 46
Fowler, Charles Evan ... 48
Fuller & McClintock ... 48

G

Gillette Publishing Co. ... 47-49
Graver Tank & Mfg. Co. ... 47
Great Western Electro-Chemical Co. ... 11

H

Hellige, Inc. ... 47
Hill, Jr., Nicholas S. ... 48
Hudson Coal Co. ... 9
Hydraulic Development Corp. ... 8

I

Industrial Chemical Sales Co., Inc. ... 4
Innis, Speiden & Co. ... 10
International Filter Co. ... 9

K

Kimberly, A. Elliott ... 48
Knowles, Inc., Morris ... 48

L

Lakeside Engineering Corp. ... 11
LaMotte Chemical Products Co. ... 46
Lock Joint Pipe Co. ... 45
Lynchburg Foundry Co. ... 45

M

Mathieson Alkali Works, Inc. ... 6
Metcalf & Eddy ... 48

P

Pacific Flush Tank Co. ... 47
Pennsylvania Salt Mfg. Co. ... Third Cover
Pirnie, Malcolm ... 48
Potter, Alexander ... 48
Powell, Sheppard T. ... 48

R

Roberts Filter Mfg. Co. ... 45
Rosing, Inc., Astrid S. ... 48
Royer Foundry & Mach. Co. ... 10

S

Simplex Valve & Meter Co. ... 8
Sonken-Galamba Corp. ... 46
South Bend Foundry Co. ... 46

T

Taylor Audit Co., P. H. ... 48
Traylor Hotel ... 49

U

United States Pipe & Foundry Co. ... 12

W

Wallace & Tiernan Co. ... Back Cover
Warren-Knight Co., ... 46
Whitman & Howard ... 48
Wilson, P. S. ... 48

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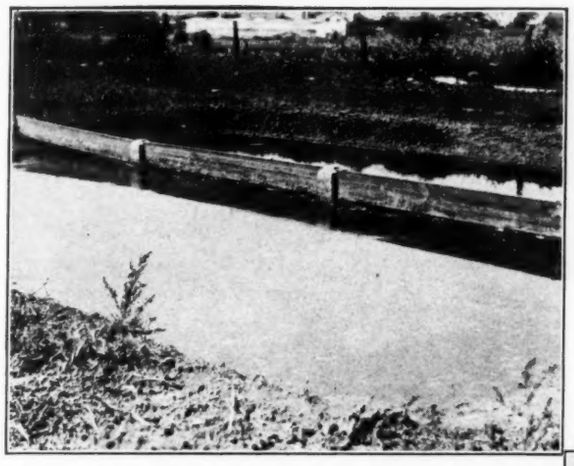

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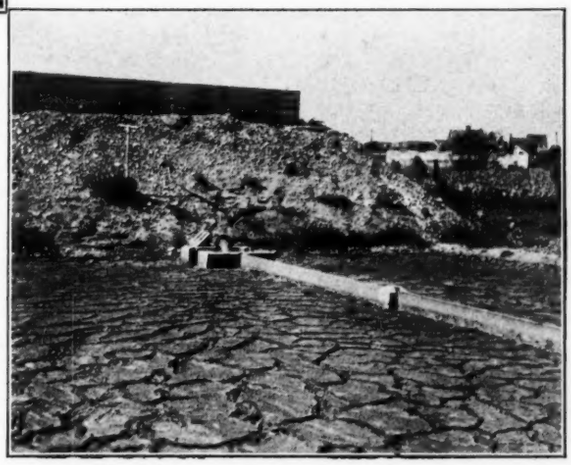

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